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BULLETIN

OF

THE NEW YORK BOTANICAL GARDEN

VOLUME III, 1903–1905

BULLETIN

OF

The New York Botanical Garden

VOLUME III

WITH 37 PLATES

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BULLETIN

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[ISSUED NOVEMBER 11, 1903]

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BULLETIN

OF

The New York Botanical Garden

Vol. 3. No. 9.

BOTANICAL CONTRIBUTIONS.

New or Noteworthy North American Crassulaceae.

BY N. L. BRITTON AND J. N. ROSE.

TILLAEASTRUM Britton.

Bulliarda DC. Bull. Soc. Philom. 3^{49}: 1. 1801. Not Neck. 1790.

Type species, *Tillaea aquatica* L.

1. TILLAEASTRUM AQUATICUM (L.) Britton.

Tillaea aquatica L. Sp. Pl. 128. 1753.

Tillaea simplex Nutt. Jour. Acad. Phila. 1: 114. 1817.

Bulliarda aquatica DC. Prod. 3: 382. 1828.

Tillaea angustifolia Nutt.; T. & G. Fl. N. Am. 1: 558. 1840.

Tillaea angustifolia Bolanderi S. Wats. in Brew. & Wats. Bot. Cal. 1: 209. 1876.

Tillaea Bolanderi Greene, Fl. Fran. 183. 1891.

Crassula aquatica Schoenl. in E. & P. Nat. Pfl. 3^{2a}: 37. 891. 1891.

In mud, Nova Scotia to Maryland, Louisiana and Texas, Washington to Lower California and Colorado. Europe to northern Africa.

2. TILLAEASTRUM VIRIDE (S. Wats.) Britton.

Tillaea viridis S. Wats. Proc. Am. Acad. 23: 272. 1888.

Chihuahua. San Luis Potosi.

3. TILLAEASTRUM DRUMMONDII (T. & G.) Britton.

Tillaea Drummondii T. & G. Fl. N. Am. 1: 558. 1840.

Muddy places, Louisiana to San Luis Potosi, California and Washington.

4. **Tillaeastrum Pringlei** Rose,* sp. nov.

Delicate little plants growing in masses in damp mountain soil, 2–3 cm. high; leaves linear, 3–4 mm. long, acute; flowers axillary, solitary on very short peduncles, 1 mm. or less long, in fruit becoming 3 mm. long; carpels obtuse; seeds oblong, not papillose-roughened.

Collected by C. G. Pringle, September, 1896, Serrania de Ajusco, Federal District, Mexico (no. 6517).

5. Tillaeastrum Vaillantii (Willd.) Britton.

Tillaea Vaillantii Willd. Sp. Pl. 1: 720. 1798.

Bulliarda Vaillantii DC. Pl. Grasses, *pl. 74.* 1799.

Crassula Vaillantii Schoenl. in E. & P. Nat. Pfl. 3^{2a}: 37. 1891.

Prince Edward Island. Europe and northern Africa.

OLIVERELLA Rose, gen. nov.

Caulescent and much branched perennial; leaves flat but fleshy. Flowers usually solitary (sometimes in pairs), terminating leafy branches. Calyx-lobes unequal, linear, spreading. Corolla very large and elongated, its lobes free nearly to the base, thickish. Stamens 10. Carpels 5, free, rather short, terminated by long slender styles.

Named for Mr. George W. Oliver, for many years connected with the National Botanic Garden at Washington but now employed as an expert in the Department of Agriculture. It was due to Mr. Oliver that we were able to flower this beautiful plant, as well as many more of the species described below, and it gives me great pleasure to name for him this, the most remarkable of all the Crassulaceae of America.

Oliverella elegans Rose, sp. nov.

Caulescent, 3–5 dm. high, branching throughout, densely pubescent; leaves closely set near the ends of young branches, gradually falling away below, oblanceolate to spatulate, thick, but flattened except at base, acute, pubescent, 2–3 cm. long; flowering branches slender, 1 dm. long, with some scattered leaves, but finally becoming naked, terminated by one or two flowers; calyx-lobes linear, spreading, very unequal, green, the longer ones 15 mm. long; corolla 2.5–3 cm. long, bright red except the yellow tips.

Found in cultivation at Amacamaca, near City of Mexico, by J. N. Rose, August, 1901 (no. 6073), and flowered in succulent house, Department of Agriculture, in June, 1902 and July, 1903.

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* These descriptions of new species by Dr. Rose are published with the permission of the Secretary of the Smithsonian Institution. All his types unless otherwise stated are in the National Herbarium.

CLEMENTSIA Rose, gen. nov.

Perennial herb with a thick elongated root, and usually with several stems from the base. Stem-leaves numerous. Flowers in a more or less elongated dense spike or raceme. Calyx-segments linear to linear-lanceolate. Petals distinct, rose-colored. Stamens 10, 5 alternating with the petals and distinct, 5 opposite the petals and each adnate to its corresponding petal near the middle. Scales 5, prominent, flat, obtuse. Carpels 5, erect.

Named in honor of Professor Frederic E. Clements of the University of Nebraska, who has prosecuted extensive investigations on the plants of Colorado.

Type species, *Sedum rhodanthum* A. Gray.

CLEMENTSIA RHODANTHA (A. Gray) Rose.

Sedum rhodanthum A. Gray, Am. Jour. Sci. II. **33**: 405. 1862.

In meadows and along streams in the Rocky Mountains, Arizona and Utah to Montana.

VILLADIA Rose, gen. nov.

Perennial by fleshy or somewhat tuberous roots; caulescent. Leaves terete and turgid. Inflorescence an equilateral raceme or spike or a very compact panicle. Flowers small. Calyx-lobes 5, nearly equal. Corolla not 5-angled. Petals thin, either distinct or slightly united. Stamens 10; anthers broad and short. Scales conspicuous, thin. Carpels erect.

Named for Dr. Manuel M. Villada, one of the prominent scientific men of Mexico, who has for many years been editor of *La Naturaleza*.

Type species, *Cotyledon parviflora* Hemsl.

1. VILLADIA TEXANA (J. G. Smith) Rose.

Sedum Texanum J. G. Smith, Rep. Missouri Bot. Gard. **6**: 114. *pl. 50.* 1895.

Eastern Texas.

2. Villadia imbricata Rose, sp. nov.

Caespitose; sterile branches thickly set with small ovate imbricated leaves; flowering branches 2–6 cm. long, thickly set with imbricated leaves; leaves oval, 3 mm. long, acute, keeled on the back, at least in dry specimens, very pale, thickly set with minute tubercles; inflorescence a very short compact leafy spike; sepals distinct, leaf-like, shorter than the corolla; corolla "white,"

4–5 mm. long, its lobes erect, united for about a third their length at base.

Collected by E. W. Nelson near Reyes, Oaxaca, October 20, 1894 (no. 1767).

3. **Villadia cucullata** Rose, sp. nov.

✓

Perennial by rather fleshy roots; stems 1–1.5 dm. high, simple, glabrous, spotted; leaves small, narrow, glabrous, projecting backward at base; inflorescence a short spike or equilateral raceme, 3–4 cm. long; flowers subtended by small ovate bracts; sepals ovate, green, 2 mm. long, distinct; corolla reddish, 3 mm. long, its tube 1 mm. long, its lobes hooded, denticulate on the margin.

Collected by Dr. E. Palmer near Saltillo, Coahuila, Mexico, June, 1898 (no. 374). Only a single specimen was seen, growing under bushes.

4. **Villadia Nelsoni** Rose, sp. nov.

Caulescent, 2–3 dm. high, more or less branched throughout, somewhat roughened; leaves spatulate, flattened (at least in dried specimens), 1–1.5 cm. long; inflorescence spicate; flowers sessile; sepals ovate, 2 mm. long; corolla "white," 5–6 mm. long; carpels long-attenuate.

Collected by E. W. Nelson on road between Ayusinapa and Petatlan, Guerrero, alt. 1500 to 2100 meters, December 14, 1894 (no. 2114).

5. **Villadia Pringlei** Rose, sp. nov.

Perennial by fleshy roots, much branched at base; stems 5–15 cm. high, green; stem-leaves linear in outline, 1–1.5 cm. long; inflorescence sometimes 10 cm. long, either spicate, or a compact panicle; sepals somewhat unequal, distinct, the longer ones 5 mm. long; corolla white (?), 6 mm. long.

Collected by C. G. Pringle in meager soil of dry ledges in the Sierra Madre of Chihuahua, Mexico, October 17, 1887 (no. 1238).

6. **Villadia minutiflora** Rose, sp. nov.

Perennial, with a woody or frutescent base sending up from below numerous simple ascending or erect branches 1–2 dm. tall, terminating in an open spike or raceme or a very narrow compact panicle; leaves very numerous, ascending, linear in outline, perhaps turgid and terete in fresh specimens, 6–10 mm. long, about 1 mm. wide, obtuse, projecting below the insertion at base, pubescent with short stiff hairs; flowers sessile or subsessile, either solitary and axillary or borne in short one-sided spikes; sepals somewhat unequal, 1–2 mm. long, distinct; petals white, 3 mm. long, united at base; stamens shorter than the petals, borne on the corolla-tube; appendages rounded at apex, produced below into a

slender stalk; carpels erect, short; styles short, spreading or even hooked.

Collected by C. G. Pringle on cold ledges of Sierra de San Felipe, altitude 2,550 meters, October 13, 1894 (no. 4981).

7. **Villadia ramosissima** Rose, sp. nov.

Shrubby and much branched at base; branches reddish, glabrous, at first erect, but in age spreading over other plants; leaves rigid, set nearly at right angles to the stems, turgid and nearly terete in section, ovate to oblong, glabrous; sterile branches short and closely covered with pale gray or purplish leaves; inflorescence a loose leafy spike, each flower borne in the axil of a leaf and with a smaller leaf on each side; sepals green, distinct, ovate, acute, 2 mm. long; corolla campanulate, white or with a pinkish tinge (in cultivated specimens), its tube short, but very distinct, the lobes acute, 4 mm. long; stamens 10, borne on the corolla-tube, much shorter than the petals; anthers purplish; appendages conspicuous, yellow, 1 mm. broad; carpels erect (at least when young), distinct.

Common on the limestone hills near Tehuacan, Puebla. Described from living specimens, collected by J. N. Rose, 1901, which flowered in Washington in 1902 (no. 6417).

Pringle's no. 6052 from Sierra de San Felipe, Oaxaca, and Lucius C. Smith's no. 965 from La Solidad de Etla, Oaxaca, are, perhaps, to be referred to this species, although the petals seem to be distinctly reddish.

8. VILLADIA SQUAMULOSA (S. Wats.) Rose.

Cotyledon parviflora squamulosa S. Wats. Proc. Am. Acad. 22: 473. 1887.

Sedum squamulosum S. Wats. *l. c.*

Northern Mexico. Very rare, or at least little known.

9. VILLADIA PARVIFLORA (Hemsl.) Rose.

Cotyledon parviflora Hemsl. Diag. Pl. Nov. 1: 9. 1878.

High valleys of Central Mexico.

ECHEVERIA DC. Prod. 3: 401. 1828.

Type species, *Cotyledon coccinea* Cav.

Echeveria pulvinata Rose, sp. nov.

Caulescent, 12 cm. high, naked below, somewhat branching; young branches, leaves and sepals covered with a dense white velvety pubescence; leaves clustered in a rosette at the top, obovate, tapering to a narrow base, 2.5–3 cm. long, 2 cm. broad, rounded at apex

and apiculate, 5–6 mm. thick; flowers in a leafy raceme; pedicels 10–12 mm. long, bracteolate; sepals ovate, acute, unequal, the longest about half the length of the corolla; corolla scarlet, sharply 5-angled, 18–20 mm. long, pubescent without, the lobes apiculate.

Living specimens were collected by J. N. Rose and Walter Hough in Tomellin Cañon, Oaxaca, June 15, 1899, and flowered in the Washington Botanic Garden in April, 1900 (no. 4994, type). Herbarium specimens had previously been collected near the same locality by Mr. Pringle (no. 5641) and by Prof. C. Conzatti on Sierra de San Felipe (no. 107). This is a very singular species, with thick velvety leaves and bright scarlet flowers.

ECHEVERIA PRINGLEI (S. Wats.) Rose.

Cotyledon Pringlei S. Wats. Proc. Am. Acad. **25**: 148. 1890.

Only known from type specimens collected by C. G. Pringle near Guadalajara, Mexico.

Echeveria montana Rose, sp. nov.

Caulescent; leaves in a dense rosette at the top of the stem, orbicular or obovate, somewhat narrowed below, glabrous, 5–6 cm. long; flowering stems somewhat granular-roughened above, rather densely leafy-bracted below, 2–3 dm. long, many-flowered; inflorescence an equilateral raceme; sepals ovate-lanceolate, 6–7 mm. long; corolla 1 cm. long.

Collected on ledges, trees, etc., by C. G. Pringle on the Sierra de San Felipe, June 16, 1894 (no. 4706, type). Here seems to belong Charles L. Smith's no. 860 from the same locality. Resembling somewhat *E. Pringlei*, but not pubescent.

Echeveria australis Rose, sp. nov.

Caulescent, 2–3 dm. long, or 5–6 dm. including the inflorescence, glaucous; leaves broadly spatulate, rounded at apex, 3–7 cm. long, sometimes 3 cm. broad and spoon-shaped, somewhat glaucous and often purplish, thickly set at apex of branches, early falling off below; flowering branches stout, bearing numerous large oblong bract-like leaves; inflorescence an elongated equilateral raceme or sometimes more compound, forming a narrow panicle; pedicels 1 cm. long, or less, slender; flower-buds strongly 5-angled, acute; sepals unequal, the longer ones 12 mm. long, ovate-oblong, purplish, glaucous, nearly or quite free to the base; petals bright red, thickish, a little longer than the longest sepals, nearly distinct, cup-shaped at base; stamens 10, the 5 opposite the sepals borne on petals about one fourth the distance above the base.

Distributed by J. Donnell Smith as *Sedum bicolor* (no. 3633) and *Cotyledon Peruviana* (no. 7308), from both of which it seems to differ. H. Pittier has also sent abundant living material from San José, Costa Rica (December, 1902) from which the above description is drawn and which is taken as the type of the species.

Echeveria maculata Rose, sp. nov.

Acaulescent, glabrous throughout; basal leaves in a dense rosette, elongated-lanceolate, thickish, about 1 dm. long, 1.5–2 cm. broad, acute, dark green and somewhat mottled; flowering branches stout, 6–8 dm. long, their lower leaves 8–10 cm. long; inflorescence paniculate, the lower branches bearing 3 or 4 sessile flowers arranged along one side of the branch, the upper flowers in the panicle axillary and sessile; sepals very unequal, somewhat spreading, fleshy, acute; corolla pale lemon-yellow, 10 mm. long; lobes free nearly to the base, acute at tip and slightly spreading.

Collected by J. N. Rose near Dublan, Hidalgo, Mexico, July 2, 1901 (no. 5412), and sent to Washington where it has repeatedly flowered.

This species is somewhat similar to *E. mucronata*, but is certainly distinct.

Echeveria platyphylla Rose, sp. nov.

Acaulescent, glabrous throughout; basal leaves in a dense rosette, somewhat rhomboid in outline, thinnish, pale green, acuminate, tipped with a slender cusp, 4–5 cm. long, about 2 cm. broad; flowering branch 2–3 dm. long, bearing small scattered leaves below; flowers 15 to 20, arranged in an equilateral raceme; pedicels 3 mm. long or less; sepals green, thickish, linear, erect, subequal; corolla reddish yellow, lobes 9 mm. long, tips spreading even in age, tube very short, 1–2 mm. long.

Collected living by J. N. Rose, Valley of Mexico, July, 1901 (no. 6393). The specimens have frequently flowered in cultivation at Washington. This species must be close to *E. mucronata*, but has very different foliage. The above description is drawn entirely from living plants. The Department of Agriculture has many seedlings for distribution.

Echeveria tenuis Rose, sp. nov.

Acaulescent, glabrous throughout; leaves fleshy, numerous, forming a flattened rosette, oblong, 4–5 cm. long, much narrowed at base, acute; flowering branches slender, at first nodding or scorpioid, their leaves linear or at least narrow, with a small rounded spur at base; flowers sessile or nearly so; sepals very unequal,

broadly ovate to linear; corolla 9 mm. long, the segments in dry specimens keeled on the back, with scarious margins, not connivent in age, united for about one fourth their length.

Collected by J. N. Rose among rocks on top of mountains near Monte Escobedo, Zacatecas, Mexico, August 26, 1897 (no. 2640*a*). This species resembles *E. Desmetiana* in its sessile flowers, but the leaves are of different shape, and the bracts are not two-spurred at base.

Echeveria humilis Rose, sp. nov.

Acaulescent, or with a short woody caudex, glabrous throughout; basal leaves in a dense rosette, thickish, lanceolate, acute, 5–6 cm. long; flowering stems about 1 dm. long, rather weak, leafy below; inflorescence a few-flowered secund raceme, sometimes paniculately branched; pedicels 2–3 mm. long, bractless; sepals lanceolate, very unequal, the longer 4–5 mm. long, acute; corolla 8–9 mm. long, its segments united for about one fourth their length.

Collected by Parry and Palmer, State of San Luis Potosi, 1878 (no. 233 in part, type), and in the same state by J. G. Schaffner, 1879 (no. 769).

Echeveria obtusifolia Rose, sp. nov.

Acaulescent or perhaps sometimes shortly caulescent, glabrous throughout; leaves forming a spreading rosette 2 dm. broad, oblanceolate, rounded at apex, 3.5 cm. broad at widest part, narrowed to 5 mm. at base, thinnish (at least in herbarium specimens); flowering branches 2–3 dm. long (naked in herbarium specimens seen); inflorescence a one-sided (?) raceme, erect or at least becoming so, 12–20-flowered; lower pedicels 10 mm. long, ascending; sepals unequal, ovate; corolla reddish, 10–12 mm. long, rather broad, not strongly angled (as far as indicated by dried specimens).

Collected by C. G. Pringle on bluffs of mountain cañon near Cuernavaca, Morelos, altitude 3,150 meters, September 17, 1899 (no. 7734). This species seems very distinct from all others known to the writer. In foliage it suggests *E. mucronata*, but the inflorescence is secund, as in the *E. glauca* type.

Echeveria heterosepala Rose, sp. nov.

Acaulescent; basal leaves forming a dense rosette, obovate, somewhat acuminate, tipped with a long mucro, glabrous, perhaps also glaucous, 3 cm. long (in specimens seen); leaves on lower part of flowering branches large, above somewhat reduced; inflorescence a secund raceme, 12–15-flowered, at first nodding; lower pedicels longer, 6–7 mm. long; bractlets ascending; sepals ovate, more or

less united at base, very unequal, the longer ones 6–7 mm. long; corolla reddish, short and broad, 8–9 mm. long.

Collected by C. G. Pringle on calcareous hills near Tehuacan, Puebla, August, 1897 (no. 7499, type), and by Henry E. Seaton near Esperanza in the same state, August 4, 1891 (no. 333*a*).

Very similar to *E. glauca* in habit, but with different flowers.

Echeveria cuspidata Rose, sp. nov.

Acaulescent; leaves in a dense rosette, sometimes a hundred or more, very glaucous on both sides, somewhat tinged with red, obovate in outline, about 6 cm. long, often 3.5 cm. broad at widest point, cuspidate; flowering stalk 2–4 dm. long, glabrous and pale, sometimes rose-colored, bearing throughout its length scattered small ovate leaves free at base and acute at each end; inflorescence a simple secund raceme, at first strongly nodding, about 15-flowered; buds arranged in two rows, obtusish; lower pedicels elongated, 10 mm. long or less; sepals unequal, all much shorter than the corolla, ovate, acute; corolla 1 cm. long, purplish with yellowish slightly spreading acute tips, the lobes united for about one fourth their length; stamens 10, all inserted on the corolla-tube, the 5 opposite the sepals inserted at the top of the tube, the other 5 inserted a little lower down on the tube; carpels erect, free to the base.

Common at Saltillo, Mexico. This description is drawn from specimens collected by Dr. E. Palmer in 1902, which flowered in Washington in February, 1903 (Rose, no. 509).

Echeveria minutiflora Rose, sp. nov.

Flowering stems glaucous, clothed with thick leaves. Basal leaves forming a rosette, 7–10 cm. long, oblong, obtuse, light green, glabrous, tapering at base into a short petiole; inflorescence composed of small cymes, single flowers and twinned flowers arranged in a thick leafy spike; sepals longer than the corolla, somewhat unequal; corolla-segments spreading, ovate, acute, separated nearly to the base, greenish yellow spotted with red.

Collected by C. G. Pringle near Tehuacan, Puebla, August 1, 1897 (no. 7500, type); by J. N. Rose and Walter Hough between Tepeaca and Santa Rosa, Puebla, June 27, 1899 (no. 4704); and perhaps also by E. W. Nelson at Huajuapam, Oaxaca, November 16, 1894 (no. 1980).

Habit and inflorescence of *Villadia parviflora*, but with larger flowers and acute corolla-lobes.

Echeveria Schaffneri (S. Wats.) Rose.

Cotyledon Schaffneri S. Wats. Proc. Am. Acad. 17: 354. 1882.

Collected by C. G. Pringle on alkaline plains, Hacienda de An

gostura, State of San Luis Potosi, June 27, 1891 (no. 3766), and distributed as *C. Grayi*, a very different plant.

ECHEVERIA SUBRIGIDA (Rob. & Sea.) Rose.

Cotyledon subrigida Rob. & Sea. Proc. Am. Acad. **28**: 105. 1893.

Only known from Tultenango Cañon, State of Mexico, where it was first collected by Mr. Pringle in October, 1892 (no. 4326). It is a most beautiful species, worthy of general cultivation. A single specimen collected by Mr. Rose, now in the Missouri Botanical Garden, is the only one in cultivation.

Echeveria Palmeri Rose, sp. nov.

Acaulescent; leaves numerous, erect or slightly spreading, pale green, at first somewhat glaucous, with reddish margins, rhomboid or oblanceolate, the largest ones 2 dm. long, 1 dm. broad at widest point, narrowed at base and there 2–4 cm. broad, flat and fleshy, but not very thick except at base, acute; flowering branches thick and stout, 6–8 dm. high, green and slightly glaucous below, reddish or rose-colored above, bearing a few scattered oblong leaves 4–5 cm. long; inflorescence a rather compact panicle 1–2 dm. long, its branches somewhat glaucous, short, 3–4-flowered; pedicels stout, 3–6 mm. long; calyx deeply 5-parted, its lobes very unequal, linear to narrowly ovate, acute, the longer ones 10 mm. long; corolla-buds sharply 5-angled, acute, broadly ovate in outline, somewhat glaucous; corolla 2 cm. long, 12 mm. broad at base, reddish-yellow, deeply parted into 5 lobes, the tube proper only 3 mm. long, lobes oblong, thickish, somewhat spreading at tip but connivent in age, gibbous at base; stamens 10, all inserted at top of corolla-tube, those opposite the petals broad at base; appendages lunate, deep purple, depressed in the center; carpels erect, distinct or nearly so, tapering into the slender purple styles; ovules many.

Described from living specimens sent by Dr. E. Palmer from the high mountains about Alvarez near the city of San Luis Potosi. One of the showiest of all the Echeverias. Perhaps nearest *E. subrigida*, but with different inflorescence and larger leaves.

COURANTIA Lem. Jard. Fleur. 1: Misc. 92. 1851.

Caulescent. Leaves alternate, closely set, flat and broad. Inflorescence a dense spike; bracts brightly colored. Calyx-lobes equal (?), linear, brightly colored, as long as the corolla. Corolla not 5-angled, yellow, 5-parted. Stamens 10, borne at base of the corolla; filaments united into a tube for half their length; scales none (?). Carpels widely spreading.

Type of genus, *Echeveria rosea* Lindl.

COURANTIA ROSEA (Lindl.) Lem. Jard. Fleur. 3: 244. 1853.

Echeveria rosea Lindl. Bot. Reg. 28: *pl. 22.* 1842.

Cotyledon roseata Baker, in Saund. Refug. Bot. sub. *pl. 55*, no. 3. 1869.

Courantia echeverioides Lem. Jard. Fleur. 1: Misc. 92. 1851.

Mexico.

PACHYPHYTUM Link, Klotzsch & Otto, Allgem. Gartenz. 9: 9. 1841.

Caulescent and more or less branched; leaves very thick, often terete. Flowers solitary or arranged in secund racemes. Calyx deeply lobed, the lobes appressed to the corolla, ovate to oblong, equal or unequal, shorter or longer than the corolla. Corolla deeply 5-parted, not at all angled; petals erect below, spreading above. Stamens 10; the 5 alternating with the petals free from the corolla; the other 5 borne on the petals, each with a pair of appendages at the base. Scales broad. Carpels 5, erect, free to the base; styles short.

Three species, all Mexican.

Type species, *Pachyphytum bracteosum* Link, Klotzsch & Otto.

Pachyphytum uniflorum Rose, sp. nov.

Perennial, caulescent, about 2 dm. high, either simple, or branched at base, usually erect and stout, woody below; leaves closely set on upper parts of branches, falling off below, very turgid, but slightly flattened, 3–5 cm. long, only slightly narrowed below, rounded at apex, not glaucous, but pale green except near the apex, or even reddish throughout; flower-stems slender, erect or nearly so, appearing from the axils of the uppermost leaves of the rosette, pinkish, not glaucous, naked below, but with about 9 small scattered leaves above, these about 1 cm. long, greenish or purplish, minutely auricled at base; calyx 5-lobed, 8 mm. long, its lobes ovate, pinkish or greenish, acute; corolla 12 mm. long, 5 mm. broad, little or not at all angled in bud; petals spreading, free nearly or quite to the base, acute; stamens 10, the five opposite the sepals free, the other 5 borne on the petals each with two broad truncate appendages at its base; scales broad; carpels 5, erect, distinct.

Plants purchased on the streets of San Luis Potosi, Mexico, by Dr. E. Palmer in 1902 (type). They are said to have come from a mountain cañon in sight of the city. These plants are sold in San Luis Potosi and grown in shady courtyards.

URBINIA Rose, gen. nov.

Acaulescent; leaves closely imbricate, thick and rigid. Inflorescence rather few-flowered, cymose. Calyx small, 5-lobed; lobes

ovate to lanceolate, equal or unequal, much shorter than the corolla. Corolla somewhat cone-shaped, the lobes united at base into a tube. Stamens 10, borne on the corolla. Carpels 5.

A very peculiar genus, quite distinct in its habit and calyx from *Echeveria* and well deserving to be separated. Named for Dr. Manuel Urbina, Acting Director of the National Museum of Mexico.

Type species, *Echeveria agavoides* Lem.

1. URBINIA AGAVOIDES (Lem.) Rose.

Echeveria agavoides Lem. Ill. Hort. **10**: Misc. 1. 78. 1863.

Cotyledon agavoides Baker, in Saund. Refug. Bot. **1**: *pl. 67*. 1869.

Echeveria yuccoides E. Morren, Belg. Hort. **24**: 168. 1874.

Mexico.

2. URBINIA CORDEROYI (Baker) Rose.

Echeveria Corderoyi E. Morren, Belg. Hort. **24**: 159. 1874.

Cotyledon Corderoyi Baker, Gard. Chron. **1**: 599. 1874.

Very near *E. agavoides* but described as having more leaves and flowers.

Northern Mexico.

3. **Urbinia obscura** Rose, sp. nov.

Leaves ovate, 8–9 cm. long, 4–5 cm. broad at base, thick but flattened, somewhat rounded at the base; flowering stems thickish, covered with many narrow leaves, the larger ones 3 cm. long, free at base, green except the pungent almost spiny tip; inflorescence a 2-branched cyme; flowers about 10; calyx small, with 5 very unequal lanceolate teeth; corolla 12 mm. long, bright rose colored below, but the slightly spreading lobes yellow.

Described from a plant in collections of the New York Botanical Garden, received from Mr. W. B. Kunhardt; a flowering specimen taken from this plant is in the National Herbarium.

DUDLEYA Britton & Rose, gen. nov.

Caulescent or acaulescent perennials with flat linear to ovate basal leaves and yellow, orange, red or rarely white flowers mostly in panicles. Leaves of the flowering branches usually much shorter and relatively broader than the basal ones, sessile, or clasping. Calyx conspicuous, 5-lobed, the lobes erect, linear-lanceolate to ovate, obtuse to acuminate. Corolla nearly cylindric, or somewhat angled, the segments united below the middle, erect, or their tips somewhat spreading, obtuse to acuminate. Stamens twice as many as the calyx-lobes, distinct. Carpels erect, many-seeded.

Named in honor of Professor William R. Dudley, of Stanford University.

Type species, *Echeveria lanceolata* Nutt.

1. Dudleya Rusbyi (Greene) Britton & Rose.

Cotyledon Rusbyi Greene, Bull. Torrey Club, **10**: 125. 1883.

Probably perennial, acaulescent; leaves in dense rosettes, rhomboid-ovate, 1.5–2 cm. long, acuminate, glabrous but papillose-roughened; flowering branches erect, 7–12 cm. high, glabrous; leaves of flowering stems linear, scattered and small; inflorescence a two-branched few-flowered cyme; pedicels 2–6 mm. long; calyx-lobes somewhat unequal, ovate, obtuse or acute; corolla deep red or "coral red," 10 mm. long, the lobes acuminate, the tube longer than the calyx.

The only definite locality given is the San Francisco Mountains in southern Arizona, although it has been collected also by Lemmon somewhere in Arizona, station not stated.

2. **Dudleya albiflora** Rose, sp. nov.

Perennial by a multicipital caudex 2–3 dm. in diameter and with 25 or more rosettes crowning the short stems; leaves narrow, 1–1.5 cm. broad, strap-shaped to lanceolate, 4–5 cm. long, becoming purplish, not glaucous, thick and fleshy but distinctly flattened, acute; corolla white.

Living specimens sent by T. S. Brandegee, collected at Magdalena Bay, Lower California, in the fall of 1902.

3. Dudleya pulverulenta (Nutt.) Britton & Rose.

Echeveria pulverulenta Nutt.; T. & G. Fl. N. Am. **1**: 560. 1840.

? *Cotyledon pulverulenta* Baker, in Saund. Refug. Bot. **1**: *pl. 66.* 1869.

? *Echeveria argentea* Lem. Ill. Hort. **10**: 78. 1863.

Southern California.

4. **Dudleya Anthonyi** Rose, sp. nov.

Resembling *D. pulverulenta*, but basal leaves more elongated, 2 dm. long by 4–5 cm. broad, stem-leaves seemingly narrower; pedicels slender and longer, and calyx-lobes narrower.

Collected by A. W. Anthony on San Martin Island, Lower California, July–October, 1896 (no. 123, type), July 15, 1896, March 13, 1897.

5. **Dudleya tenuis** Rose, sp. nov.

Acaulescent; leaves forming a rosette, oblong-lanceolate, 3–4 cm. long, acuminate, somewhat glaucous; flowering stems slender, 1–2 dm. high; inflorescence a slender panicle, consisting of several elongated erect branches; pedicels very short, 1 mm. long or less; calyx deeply 5-parted, its lobes ovate, acute, 2–2.5 mm. long; corolla 6–8 mm. long, rather narrow, at first yellowish, in age becoming reddish, the segments united for about one half their length.

Collected in the mountains of Lower California by C. R. Orcutt July 5, 1884 (no. 113).

6. **Dudleya angustiflora** Rose, sp. nov.

Acaulescent; leaves forming a rosette, lanceolate, 3–4 cm. long, acute or acuminate, very glaucous; flowering stems slender, 1.5–2 dm. high; inflorescence a somewhat spreading panicle with 2–4 elongated branches; pedicels slender, 4–12 mm. long; calyx glaucous, deeply 5-parted, its lobes ovate-lanceolate, acute, 3 mm. long; corolla very narrow, 10–12 mm. long, reddish (at least drying so), its segments united into a tube 2 mm. long; stamens about two thirds as long as the corolla, borne on its tube; carpels erect.

Collected by C. A. Purpus on rocks near Daunt P. O., Tulare Co., California (no. 5672).

7. **Dudleya Abramsi** Rose, sp. nov.

A very delicate little perennial with a thick caudex crowned by a dense rosette of small (2 cm. long) linear-ovate, acuminate, somewhat glaucous leaves; flowering stems slender, 6–7 cm. long, naked below, and with a few scattered ovate acute bracts above; inflorescence 2-branched (in two specimens seen), each branch bearing a secund raceme of several subsessile flowers; calyx 3 mm. long, its lobes ovate or triangular-ovate, acute, about twice as long as the tube; corolla slender, 8–9 mm. long, the tube longer than the calyx, the lobes narrow, acute, yellow, striped on the back with deep red, much longer than the slender styles and stamens.

Collected by L. R. Abrams in wet crevices of rocks west of Jacumba, near San Diego, California, June, 1903 (no. 3707).

Resembling *D. pauciflora* in habit, but with nearly sessile flowers, these suggesting *D. pumila* and *D. angustiflora;* from which, however, it is surely quite distinct.

8. **Dudleya pumila** Rose, sp. nov.

Acaulescent; leaves forming small dense rosettes, very glaucous, 2–3 cm. long, ovate, acute; flowering stems delicate, less than 1 cm. long, bearing small ovate leaves; inflorescence of 2 or 3 slender branches, ascending or spreading; pedicels 6–10 mm. long; calyx

pale, glaucous, its lobes lanceolate-ovate, 2–3 cm. long, acute or sometimes obtusish; corolla 10–13 mm. long, the lobes very narrow, acute, much longer than the stamens.

Collected by H. M. Hall on rocks of hillsides, altitude 2,100 meters, San Bernardino Mountains, California, July 19, 1899 (no. 1350). This species is near *D. angustiflora*, but with basal leaves very different in shape and stem-leaves much smaller.

9. DUDLEYA FARINOSA (Lindl.) Britton & Rose.

Echeveria farinosa Lindl. Jour. Hort. Soc. 4: 292. 1849.

Cotyledon farinosa Baker, in Saund. Refug. Bot. 1: *pl. 71.* 1869.

Coast of California.

10. **Dudleya aloides** Rose, sp. nov.

Tufted, acaulescent; leaves numerous, erect, rigid, very narrow, thick, semiterete, or the upper part subterete, 7–12 cm. long, 10–15 mm. broad at base, gradually tapering to the apex, very pale, hardly glaucous, often spotted with red; flowering stems 2–3 dm. long, reddish, as also the branches and pedicels; stem-leaves ovate, acute, slightly clasping; inflorescence paniculate; pedicels rather slender, 18–20 mm. long, ascending; calyx deeply 5-cleft, the lobes triangular-ovate, acute, 4 mm. long; corolla broad, yellow, drying reddish (?), 10 mm. long, the lobes acute.

Collected at San Felipe, San Diego Co., California, by T. S. Brandegee, April 30, 1894, also by C. R. Orcutt, April, 1903 (living specimens in Department of Agriculture greenhouse, type), and by H. M. Hall, May, 1899.

11. DUDLEYA SAXOSA (M. E. Jones) Britton & Rose.

Cotyledon saxosum M. E. Jones, Contr. West. Bot. 8: 28. 1898.

Panamint Cañon, California.

12. DUDLEYA SETCHELLII (Jepson) Britton & Rose.

Cotyledon laxa var. *Setchellii* Jepson, Fl. West. Mid. Calif. 267. 1901.

Flowering stems numerous, from the crown of a short thick caudex, about 3 dm. high; leaves very glaucous, numerous, lanceolate to linear-lanceolate, long-acuminate; leaves of flowering stem linear, acuminate, the lower ones elongated; inflorescence a very narrow panicle; pedicels rather stout, ascending, 3–5 mm. long; calyx-lobes lanceolate, acute; corolla pale yellow, its segments narrowly oblong, acute, united at base into a very short tube; stamens much shorter than the corolla.

Coyote Creek, Santa Clara Co., California.

13. **Dudleya grandiflora** Rose, sp. nov.

Caudex very thick, crowned by a dense rosette; basal leaves strap-shaped, slightly broadened at insertion and gradually tapering from the base to apex, rather thin, 1–1.5 dm. long, 1–2 cm. broad just above the base, very glaucous on both sides, especially when very young; flowering stalk 3–5 dm. long, bright red especially above, bearing scattered ovate acuminate leaves; inflorescence rather compact, consisting of a few upright secund racemes; pedicels, especially the lower ones, elongated, 1–1.5 cm. long; calyx usually red, deeply 5-lobed, the lobes ovate, acute, about half the length of the corolla; corolla greenish-yellow, becoming reddish in age, 10 mm. long, erect except the spreading acute tips, its segments united at the base into a very short tube 2 mm. long; stamens shorter than the corolla, attached to its base; carpels erect, distinct.

Collected by T. S. Brandegee, at Whitewater, near Banning, California.

14. Dudleya linearis (Greene) Britton & Rose.

Cotyledon linearis Greene, Pittonia, 1: 285. 1889.

Caudex thick and fleshy, crowned by a dense rosette of leaves; leaves "light green not farinose," broadly linear, acuminate, 3–7.5 cm. long, 6–9 mm. broad, thick; flowering stems 1–1.5 cm. long, more or less bracteate; inflorescence consisting of 2 or 3 secund racemes, more or less glaucous, rather compact; pedicels 4 mm. long or less; calyx deeply 5-lobed, lobes ovate-lanceolate, acute, 5 mm. long; corolla greenish-yellow, 8–9 mm. long, its tube shorter than the calyx.

San Benito Island, off the coast of Lower California.

15. **Dudleya cultrata** Rose, sp. nov.

Caespitose, the caudex bearing several rosettes of leaves; leaves strap-shaped, not glaucous, 6–10 cm. long, gradually tapering from a rather wide base, 10–12 mm. broad, rather thickish, terete near the apex, acute, sometimes sharply so; flowering branch about 30 cm. long, naked below and with scattered leaves above; inflorescence of a few more or less elongated racemes; calyx-lobes triangular-lanceolate, acute; corolla pale yellow, rather narrow, 12 mm. long, 3 times as long as the calyx, the tube proper longer than the calyx, the segments acute; stamens shorter than the corolla; anthers orange.

Described from cultivated plants sent by C. R. Orcutt, which are said to have come from San Quintin, Lower California (type). At the same station similar material was collected by T. S. Brandegee, May 23, 1889.

16. **Dudleya Greenei** Rose, sp. nov.

Caudex short and thick; leaves in rosettes, numerous, strap-shaped, 6–7 cm. long, 15 mm. broad at base, acute, very glaucous, drying thick and leathery; flowering stalk 3–4 dm. high, bearing scattered ovate acuminate leaves; inflorescence consisting of numerous secund racemes; pedicels stout, ascending, 2–4 mm. long; calyx 4 mm. high, deeply 5-parted, the lobes ovate and acute; corolla 8–10 mm. long, its tube 2 mm. long.

Only known from specimens collected by Prof. E. L. Greene on the island of Santa Cruz off the coast of southern California, July and August, 1886. Type in Herb. California Academy of Sciences; photograph and fragment in U. S. National Herbarium.

17. **Dudleya Hallii** Rose, sp. nov.

Acaulescent; basal leaves erect or spreading, elongated-lanceolate, acute, very pale and glaucous, thickish, 10–12 cm. long; flowering stems stout, 3–4 dm. long, their leaves ovate, the lower ones somewhat elongated, slightly cordate at base; inflorescence a rather short panicle, not at all glaucous; pedicels very short (about 2 mm. long); calyx-lobes lanceolate, acute, 5 mm. long; corolla 15 mm. long, pale green tinged with rose.

Collected by H. M. Hall near Riverside, California, in 1902, and flowered in Washington, May, 1903 (no. 3722).

18. **Dudleya Candelabrum** Rose, sp. nov.

Basal leaves in a dense broad rosette, oblong-lanceolate, 10–15 cm. long, 3 cm. broad near the base, perhaps not at all glaucous, drying rather thin; flowering stalk about 3 dm. long, rather stout, its leaves lanceolate, acuminate, thin; inflorescence (in herbarium specimens at least) resembling a candelabrum, 20 cm. high, 25 cm. broad at top, each branch an elongated secund raceme; pedicels short (1–4 mm. long); calyx 5–7 mm. long, deeply parted into lanceolate acuminate lobes; corolla 5–9 mm. long.

Collected by Prof. E. L. Greene on the island of Santa Cruz, off the coast of southern California, July and August, 1886; type in Herb. California Academy of Sciences, photograph in U. S. National Herbarium.

19. **Dudleya Bryceae** Britton, sp. nov.

Caudex stout, short; basal leaves very numerous, lanceolate to oblong-lanceolate, 6–8 cm. long, 2–3 cm. wide, flat, about 2 mm. thick, pale green, somewhat shining, sharply acuminate; flowering stems ascending from the lower axils, about 3 dm. long, their leaves lanceolate, acuminate; cyme many-flowered, about 8 cm. broad; pedicels 3–6 mm. long; calyx-segments linear-lanceolate, 4 mm. long, about 1 mm. wide towards the base, gradually tapering

to an acute tip, the tube very short; corolla pale yellow, 1 cm. long, 5-ridged, its linear-lanceolate lobes about as long as its tube; carpels erect, distinct to the base.

Described from a living plant sent to the New York Botanical Garden, April, 1902, from San Diego, Cal., by Miss Mary T. Bryce; probably originally from Coronado Islands.

20. **Dudleya ingens** Rose, sp. nov.

Caudex 3 dm. high or more, densely clothed with the bases of old leaves and crowned by a rosette of large leaves 10–20 cm. long, and 3–4 cm. broad; flowering stems 5–6 dm. long; inflorescence a somewhat open panicle; calyx-lobes narrowly lanceolate, half as long as the corolla, somewhat glaucous.

Collected by T. S. Brandegee at San Telmo, Lower California, June 1, 1893. Closely resembling *D. Bryceae*, but with larger and more open panicles. Type in herb. Brandegee; fragment and photograph in U. S. National Herbarium.

21. **Dudleya candida** Britton, sp. nov.

Caudex stout, about 6 cm. high; basal leaves white-farinose all over, numerous, linear to linear-oblong, sharply acuminate, somewhat widened at the base, 5–7 cm. long, 1 cm. wide or less; flowering branch stout, about 3 dm. tall, its narrowly lanceolate leaves somewhat clasping; inflorescence dense, about 6 cm. broad; pedicels stout, 2–5 mm. long; calyx-segments linear-lanceolate, acute to acuminate, more than one half as long as the linear acute corolla-segments.

Coronado Islands, California, George Thurber, May, 1852 (no. 582).

22. **Dudleya rigidiflora** Rose, sp. nov.

Basal leaves not seen; flowering stem stout, 3–4 dm. long, purplish; inflorescence of numerous long slender secund racemes; pedicels ascending, 4–5 mm. long; calyx deeply 5-cleft, its lobes equal, fleshy, 6–7 mm. long, acuminate, somewhat glaucous; corolla reddish, 12 mm. long, the tube 5 mm. long, the lobes slender, acute and erect; stamens 10, much shorter than the corolla, all attached near the top of the corolla-tube; carpels 5, slender, erect, free to the base.

Plaza Maria, Lower California, collected by A. W. Anthony, July to October, 1896 (no. 142).

23. DUDLEYA LAXA (Lindl.) Britton & Rose.

Echeveria laxa Lindl. Jour. Hort. Soc. 4: 292. 1849.

Cotyledon laxa Benth. & Hook.; Brew. & Wats. Bot. Cal. 1: 212. 1876.

Monterey, California.

24. **Dudleya Bernardina** Britton, sp. nov.

Acaulescent, green, or the young leaves and inflorescence somewhat glaucous; basal leaves forming a rosette, spreading, obovate-spatulate to rhombic-obovate, abruptly sharp-acuminate, 5–8 cm. long, 5 cm. wide or less; flowering branch 1.5–2.5 dm. high, leafy to or near the base, its leaves lanceolate to ovate-lanceolate, acute or acuminate, sagittate-clasping; cyme 10 cm. broad or less, many-flowered; pedicels becoming 1–1.5 cm. long; calyx 5–6 mm. long, deeply 5-lobed, the lobes ovate, acute; corolla yellow, about 12 mm. long, cleft to below the middle, its lobes sharply acute; stamens about three fourths as long as the corolla.

San Bernardino Mountains, southern California; type collected by S. B. and W. F. Parish, 1881 (no. 100).

25. **Dudleya Goldmani** Rose, sp. nov.

Acaulescent; basal leaves in small dense rosettes, rhomboid-ovate, acuminate, 2–4 cm. long, green or often bronzed, more or less glaucous; flowering branches rather delicate, about 10 cm. long, their leaves small, ovate, cordate at base, acute; inflorescence few-flowered, the flat-topped cyme very glaucous; pedicels 10–15 mm. long, slender; calyx 4–5 mm. long, its lobes ovate, acutish; corolla pinkish, or deep orange, 10 mm. long, its tube very short, its lobes oblong, acutish, rather thin and perhaps more inclined to spread than in other species; stamens and styles considerably shorter than the corolla.

Collected by E. A. Goldman in Pine Valley, head of Carmel River, Monterey Co., California, August 3, 1902 (no. 763), some of the specimens flowering in Washington, 1903 (type); and by Miss Alice Eastwood, same county, Los Berros Trail, Santa Lucia Mountains, May 1–12, 1897.

26. **Dudleya minor** Rose, sp. nov.

Acaulescent, or very old plants with a carrot-shaped rootstock 5 cm. long, crowned by a small rosette of spreading leaves; leaves rhomboid-ovate, the larger ones 5–7 cm. long, narrowed at base, abruptly acuminate, glaucous; inflorescence slender, with a few elongated one-sided racemes; pedicels slender, 10–15 mm. long; calyx 5–7 mm. long, its lobes ovate to ovate-lanceolate, acute; corolla yellow or pale orange, 12 mm. long, its tube 2 mm. long.

Collected on rocky banks, San Gabriel Cañon, altitude 600 to 700 meters, Los Angeles Co., Cal., by Dr. H. E. Hasse, June, 1902 (Rose, no. 421, type). Here also seems to belong A. J. McClatchie's plant, collected in the same region, May 25, 1896.

27. **Dudleya ovatifolia** Britton, sp. nov.

Glabrous, low, green, 1.5 dm. high or less; flowering stems rigid; basal leaves ovate, shining above, acute, about 2 cm. long; leaves of the flowering stems ovate, or the lower ovate-lanceolate, obtuse, or the lower acute, 5–8 mm. long; cymes few-flowered; pedicels very slender, 1 cm. long or less; flowers about 1 cm. long; calyx-segments triangular-ovate-lanceolate, about 2.5 mm. long, nearly as long as the corolla-tube; corolla bright yellow, its segments lanceolate, acute.

Sierra Santa Monica, California, H. M. Hall, no. 3255, May, 1902.

28. DUDLEYA NEVADENSIS (S. Wats.) Britton & Rose.

Cotyledon Nevadensis S. Wats. in Brew. & Wats. Bot. Cal. 1: 212. 1876.

Mountains of middle California. Type locality, Sonora, California.

29. **Dudleya Sheldoni** Rose, sp. nov.

Acaulescent; leaves lanceolate to ovate-lanceolate, acute, very glaucous, 4–5 cm. long, somewhat thickish at base but drying thin and papery; flowering stems rather slender, purplish, 16–20 cm. high, purplish, leafy to the base; lower stem-leaves linear-lanceolate, 4 cm. long, the upper ones ovate, acute; inflorescence a rather compact panicle; pedicels rather slender, sometimes 10 mm. long; sepals reddish, ovate, acute; corolla bright yellow, 10–11 mm. long, the lobes sharply acute, spreading at tip, free nearly to base; stamens attached just above the base of the corolla, about two thirds as long as the lobes; carpels 5, erect.

Collected by Miss Alice Eastwood at the north base of Mt. Tamalpais, California, June, 1903 (type), and by E. P. Sheldon at the same place January, 1903.

30. DUDLEYA PLATTIANA (Jepson) Britton & Rose.

Cotyledon Plattiana Jepson, Fl. West. Mid. Calif. 267. 1901.
Mountains of central California.

31. DUDLEYA PURPUSI (Schum.) Britton & Rose.

Echeveria Purpusi Schum. Gartenfl. 45: 608. 1896.

Cotyledon Purpusi Nichols. Dict. Gard. Suppl. 263. 1900.

Pale green, somewhat glaucous, tufted; basal leaves 4–7 cm. long, 2 cm. wide or less, rhombic, broadest near the middle, sharply acuminate; flowering branches 1–2 dm. tall, their leaves lanceolate, acute, 2 cm. long or less, sessile, numerous; cyme 4–8 cm. broad; pedicels rather stout, longer than the flowers; flower-buds ovoid, acuminate; longer than thick; calyx-segments ovate, acutish, about

5 mm. long, one third as long as the lemon-yellow corolla; corolla-segments narrowly lanceolate, acuminate, separate nearly to the base.

Mountains of middle California.

32. **Dudleya robusta** Britton, sp. nov.

Acaulescent; basal leaves numerous, ascending, lanceolate, acuminate, light green, sometimes slightly glaucous, 10–15 cm. long, 1.5–2.5 cm. wide; flowering branches stout, leafy to or nearly to the base, 4–5 dm. high, erect-ascending, their leaves lanceolate to ovate-lanceolate, sagittate, the upper ones very small, the lower 4–6 cm. long; cyme many-flowered, about 10 cm. broad; pedicels, or some of them, at length 1–1.5 cm. long, white-glaucous; calyx 5–6 mm. long, deeply cleft, its lobes ovate, sharply acute, white-glaucous; corolla about 1.3 cm. long, orange, cleft to below the middle, the lobes acute.

Described from plants sent to New York Botanical Garden from southern California by Miss Mary T. Bryce in 1902, which flowered the same year. (N. Y. B. G. no. 12,569.)

33. **Dudleya Parishii** Rose, sp. nov.

Acaulescent; basal leaves in a rosette, lanceolate, acuminate, not very thick for this genus, not at all glaucous, becoming red; flowering stems rather stout, reddish, 3–4 dm. high; lower leaves narrowly lanceolate, upper ones smaller, ovate, only slightly clasping at base; inflorescence paniculate, somewhat flat-topped, the branches spreading; pedicels rather slender, 4–8 mm. long; calyx-lobes broadly ovate, acute (in herbarium specimens sharply acute); corolla about 10 mm. long, rather pale orange, drying quite reddish.

Collected by S. B. Parish near San Bernardino, California, altitude 300–450 meters, July 1, 1896, and in 1902 (the latter specimens the type, flowering in Washington, June, 1903); Bloody Basin, near Fort Verde, Arizona, E. A. Mearns, no. 338.

34. DUDLEYA CYMOSA (Lem.) Britton & Rose.

Echeveria cymosa Lem. Ill. Hort. 10: Suppl. 79. 1863.

Cotyledon cymosa Baker, in Saund. Refug. Bot. 1: *pl. 68.* 1869.

California.

35. **Dudleya Brandegei** Rose, sp. nov.

Acaulescent; leaves in a dense rosette, rigid, ovate-oblong, long-acuminate, the larger ones 1 dm. long, pale and slightly glaucous; flowering stems 4–6 dm. long, rather stout, reddish; inflorescence of several elongated one-sided racemes; pedicels rather stout, 1–1.5 cm. long; calyx deeply cleft into ovate-lanceolate lobes, these acute and 6–7 mm. long; corolla 10–14 mm. long, yellowish, the

segments nearly erect, a little longer than the tube; stamens shorter than the corolla, attached near the top of its tube; carpels erect, free to the base.

Living specimens sent by Mrs. T. S. Brandegee in June, 1902 (type); probably native of Lower California. In Mr. Brandegee's herbarium is a flowering specimen which seems referable here, collected by him at San Barga, Lower California, in 1889.

36. **Dudleya lurida** Rose, sp. nov.

Acaulescent; basal leaves ascending or nearly erect, very numerous, not at all glaucous at flowering time, at last deeply bronzed, lanceolate, acuminate, 10–15 cm. long, 10–22 mm. broad at the middle, fleshy but not very thick for this genus; flowering stems stout, purplish, 4–5 dm. tall, their leaves broadly ovate, acute; inflorescence paniculate, the branches elongated; pedicels 8–12 mm. long, rather slender; calyx-lobes ovate, acute, 5–6 mm. long, reddish; corolla reddish, 12–15 mm. long, the segments erect, acute.

Collected by Dr. H. E. Hasse on dry ridges, Santa Monica range, Los Angeles Co., California, June 15, 1902 (type), and by Dr. A. Davidson, San Fernando, Los Angeles Co., May 24, 1903.

37. **Dudleya pauciflora** Rose, sp. nov.

Leaves forming dense rosettes, linear, slightly broadened at base, long-acuminate, 2–3 cm. long, 1 cm. broad at base, reddish, perhaps somewhat glaucous; flowering stems 5–10 cm. long, few-leaved; inflorescence a cyme of 6–8 flowers, the longer pedicels 8–10 mm. long; calyx 5-lobed, its lobes ovate, acute, 1.5–2 mm. long; corolla-tube shorter than the calyx, its segments 5–6 mm. long, lanceolate, acute, probably reddish.

Collected on San Pedro Martin Mountain, northern Lower California, by T. S. Brandegee, May 13, 1893.

This species is perhaps nearest the following, but has different leaves and inflorescence, and smaller flowers; it was distributed as *Cotyledon attenuata*, from which it is even more distinct. Type in Herb. California Academy of Sciences; fragment and photograph in U. S. National Herbarium.

38. Dudleya nubigena (Brand.) Britton & Rose.

Cotyledon nubigena Brand. Proc. Cal. Acad. II. 3: 136. 1891.

Summits of the "Sierra de la Laguna" in southern Lower California.

39. **Dudleya Xanti** Rose, sp. nov.

Resembling *D. nubigena* but of smaller stature; basal leaves in a small but rather dense rosette, broadly ovate, 4–5 cm. long, more or less glaucous; flowering stems 2–3 dm. long, slender, usually 2-branched, forming long slender racemes; pedicels slender, 8–12 mm. long; calyx small, deeply lobed, the lobes broadly ovate, obtuse or even rounded at apex, 2–3 mm. long; corolla 8–10 mm. long, reddish, its tube usually if not always longer than the calyx; stamens much shorter than the corolla; carpels erect.

The following specimens referred here are all from the extreme southern part of Lower California: Vicinity of San Lucas, L. J. Xantus, 1859–60 (type); San José del Cabo, T. S. Brandegee, 1892 (no. 207 in part and no. 208), and from the same locality, Carlos Grabendorffer, 1898.

40. DUDLEYA RUBENS (Brand.) Britton & Rose.

Cotyledon rubens Brand. Proc. Cal. Acad. II. 2: 155. 1889.

"Cliffs near San Esteban" in the interior of central Lower California about 27° 50′ latitude.

41. **Dudleya gigantea** Rose, sp. nov.

Acaulescent or nearly so, with a thick short rootstock; basal leaves in a dense rosette, very glaucous, oblanceolate, 5–7 cm. long, drying very thin; flowering stems rather stout, about 3 cm. long; inflorescence paniculate, with numerous usually erect branches; pedicels rather slender, 5–10 mm. long, erect; calyx-lobes broadly ovate, obtuse or acutish; corolla drying deep red, 9–10 mm. long, the segments erect, acute, united at base into a short tube 1.5 mm. long.

Collected at New York Falls, Amador Co., California by Geo. Hansen, June 15, 1896.

42. **Dudleya rigida** Rose, sp. nov.

Basal leaves numerous, borne on a thick woody caudex, flat but fleshy, oblong, 5–7 cm. long, acuminate, somewhat glaucous; flowering branches long, slender and weak; inflorescence of a few (usually 2) secund racemes; pedicels slender, the lower ones longer, sometimes 10–15 mm. long; calyx-lobes ovate, longer than the tube, acute; corolla 12 mm. long, reddish, with erect segments.

Lower California, J. E. McClelland; described from a specimen which flowered in Washington.

43. DUDLEYA LANCEOLATA (Nutt.) Britton & Rose.

Echeveria lanceolata Nutt.; T. & G. Fl. N. Am. 1: 561. 1840.

Cotyledon lanceolata Benth. & Hook.; Brew. & Wats. Bot. Cal. 1: 211. 1876.

Southern California.

44. **Dudleya delicata** Rose, sp. nov.

Leaves in dense rosettes, in clusters of 4–6 or more, erect or somewhat spreading, rather narrow, broadest at the base, the outer ones 2 cm. broad, the inner ones considerably smaller and narrower, gradually tapering to an acute apex, 6–8 cm. long, fleshy but flattened, very glaucous; flowering stems slender, about 20 cm. long, the leaves ovate, acute; pedicels very short, 2–4 mm. long; calyx-lobes equal, ovate, acute, not glaucous; corolla rather narrow, greenish-yellow, the lobes slightly spreading at tip, obtuse or barely acutish, oblong, united at base into short tube barely 2 mm. long.

Collected by L. R. Abrams in Spencer Valley, near Julian, San Diego Co., California, June 22, 1903. Here seems to belong R. D. Alderson's no. 446, from Witches Creek, a nearby locality.

45. Dudleya Palmeri (S. Wats.) Britton & Rose.

Cotyledon Palmeri S. Wats. Proc. Am. Acad. 14: 292. 1879.

San Simeon Bay, San Luis Obispo Co., California. Only known from type specimens.

46. **Dudleya Brauntoni** Rose, sp. nov.

Plants caespitose, the rootstock crowned by 6–8 rosettes of leaves; leaves elongated, strap-shaped, becoming 20 cm. long and 2 cm. broad, but often at flowering time only 10 cm. long and 1 cm. broad, pale green and very glaucous on the face, acute; flowering stems usually stout, 3–6 dm. long, pale green, their lower leaves often quite large, the upper ones ovate, acute, thickish, slightly cordate at base; inflorescence at first somewhat compact, of 3 or 4 branches, these finally much elongated (10–20 cm. long); pedicels very short (not elongated in fruit), 1–3 mm. long; calyx-lobes broadly ovate, 4–5 mm. long, acute; segments of corolla pale greenish yellow, 10–12 mm. long, erect.

Collected by Ernest Braunton on Elysian Hills, Los Angeles, California, April 20, 1903 (no. 869), and May, 1903 (no. 882).

47. **Dudleya brevipes** Rose, sp. nov.

Caespitose, the rootstock crowned by a cluster of 5 or 6 rosettes of leaves; leaves lanceolate to strap-shaped, 8–10 cm. long, 10–18 mm. broad, acute to shortly acuminate, not glaucous, somewhat shining; flowering branches about 30 cm. long, naked only near the base, their leaves ovate, acute, slightly cordate at base, spreading or ascending; inflorescence of several spreading branches;

pedicels very short (3–4 mm. long); calyx deeply 5-parted, the lobes acute, glaucous; corolla-segments reddish yellow, acute.

Collected by C. R. Orcutt near Calmalli, Lower California, April, 1903 (no. 125).

48. **Dudleya compacta** Rose, sp. nov.

Rootstock crowned by a cluster of closely set rosettes of leaves; basal leaves oblong-lanceolate, rigid, very fleshy, bright shining green, sometimes 6 cm. long but usually less, 2 cm. wide or less, broadest at base, gradually narrowed toward the ovate acute tip; flowering stem 2–3 dm. long, reddish, not at all glaucous, its lower leaves ovate-oblong, the upper ones short, broadly ovate, cordate, acutish, very thick; inflorescence rather compact, of several branches bearing a few flowers; pedicels short, the lower ones 3–4 mm. long; calyx-lobes acutish, in herbarium specimens decidedly acute; corolla pale straw-colored, 8–10 mm. long, the segments acutish, spreading at tip.

Common on rocks about San Francisco Bay. Described from specimens sent by Miss Eastwood in 1903 which flowered in Washington in June, 1903.

49. **Dudleya congesta** Britton, sp. nov.

Acaulescent, green throughout, not at all glaucous; basal leaves rhombic-lanceolate to rhombic-ovate, sharply acuminate, dull, 5 cm. long or less, 1.5–2 cm. wide; flowering branch stout, about 13 cm. tall, erect, its cordate-sagittate leaves numerous, triangular, acute to acuminate, the lower 1 cm. long, the upper much smaller; cyme compound, dense, about 6 cm. broad; pedicels very stout and short, 3 mm. long or less, erect; calyx as long as or a little shorter than the pedicels, its lobes ovate, sharply acute, longer than its tube, slightly longer than wide; corolla lemon-yellow, about three times as long as the calyx, its lanceolate segments acute, separate to below the tips of the calyx-lobes.

Type sent by Miss Bryce from southern California to New York Botanical Garden in 1902; flowered June, 1903 (N. Y. B. G., no. 12703).

50. **Dudleya Eastwoodiae** Rose, sp. nov.

Caudex short, crowned by a dense rosette of leaves, these rather short-ovate, broadest at base, acute, 2–4 cm. long, green or becoming bronzed, not glaucous or only slightly so, thickish; flowering stalks rather stout, 15–25 cm. high, densely bracted, their leaves ovate, somewhat clasping; inflorescence a rather compact cyme, the branches short, densely flowered; pedicels stout and short, 2–5 mm. long; calyx small, 3–4 mm. long, cleft to below the middle, the lobes ovate and obtuse; corolla-segments yellow (not turning reddish

in age), 10–12 mm. long, oblong, obtuse, the tube very short; stamens much shorter than the corolla, equally inserted near its base.

Collected by Miss Alice Eastwood at Bodega Point, Sonora Co., California, July 4, 1900. It much resembles the glabrous-leaved *Dudleya compacta*, of the San Francisco region, but is apparently distinct. This species and the next differ from other Dudleyas of central California in their very obtuse corolla-segments.

51. **Dudleya septentrionalis** Rose, sp. nov.

Caudex crowned by several crowded rosettes of leaves covered throughout with a white powder; leaves compact in the rosettes, rather short, thickish, acute, ovate, broadest at base, 2–2.5 cm. broad; flowering stems stout, rather weak and short for the genus, 6–8 cm. long, purplish, naked below, but thickly set with small leaves above, these broadly ovate, acute; inflorescence a very compact cyme; calyx deeply cleft, glaucous, the lobes broadly ovate, acute; corolla pale greenish yellow, rather short and broad, the broad obtuse lobes thickish on the back and united at base into a very short tube.

Collected by Miss Alice Eastwood at Crescent City, Del Norte Co., California, June, 1903. This species resembles *D. farinosa* in habit and foliage but has very different flowers, and *D. Eastwoodiae* in its broad obtuse petals but in other respects is quite different. It is by far the most northern species yet discovered.

52. **Dudleya acuminata** Rose, sp. nov.

Caespitose, the 5 or 6 dense rosettes crowning a thick caudex; leaves not very numerous (12–20), erect or ascending, broadly ovate, acuminate, 4–7 cm. long, broadest at base (2–2.5 cm. broad), thickish, pale green but not glaucous; flowering stems 25–30 cm. high, naked below, their leaves 1–1.5 cm. long, ovate, acute, sagittate at base; inflorescence slightly glaucous; pedicels short, 3–6 mm. long; calyx 5 mm. long, deeply 5-cleft, the lobes triangular-ovate, acute (rather sharply so in dried specimens); corolla reddish yellow.

Collected near Calmalli, 50 miles east of Lagoon Head, Lower California, by C. R. Orcutt, April, 1903 (no. 126, type). Here I am inclined to refer T. S. Brandegee's specimens collected on Cedros Island, April 1, 1897.

53. DUDLEYA LINGULA (S. Wats.) Britton & Rose.

Cotyledon Lingula S. Wats. Proc. Am. Acad. 14: 293. 1879.

San Simeon Bay, California. Only known from type specimen.

54. DUDLEYA PANICULATA (Jepson) Britton & Rose.

Cotyledon caespitosa var. *paniculata* Jepson, Fl. West Mid. Calif. 267. 1901.

Acaulescent; leaves in a dense rosette, ovate-oblong, about 10 cm. long, at least the inner ones quite glaucous; inflorescence an elongated panicle, 20–30 cm. long; pedicels 4–10 mm. long; calyx-lobes ovate-triangular, acute; corolla pale yellow.

Morrison Cañon near Niles, California.

55. **Dudleya humilis** Rose, sp. nov.

Caespitose, clinging to the rocks, sometimes a dozen or more rosettes of leaves crowning the rootstock; leaves linear-ovate, somewhat narrowed below, acute or shortly acuminate, 3–4 cm. long, 10–15 mm. broad, very glaucous; flowering branches 2–4 cm. long, their lower leaves lanceolate, somewhat clasping; inflorescence a short panicle, few to very many-flowered; pedicels short, 2–5 mm. long; calyx-lobes ovate, acute; corolla at first pale yellow but drying reddish, 7–8 mm. long, its segments acute, somewhat spreading at tip, about twice as long as the calyx.

Described from living specimens sent by Miss Alice Eastwood from Mt. Diablo, California, June 2, 1903. Here seems to belong the plant collected on the same mountain by Dr. E. L. Greene in June, 1892.

Miss Eastwood says of this species: "The little plants were hugging the rocks very closely and it was very difficult to disengage them. They grow almost at the very summit."

56. DUDLEYA CAESPITOSA (Haw.) Britton & Rose.

Cotyledon caespitosa Haw. Misc. Nat. 180. 1803.

Cotyledon linguiformis R. Br. in Ait. Hort. Kew. Ed. 2, 3: 109. 1811.

Cotyledon reflexa Willd. Enum. Hort. Berol. Suppl. 24. 1813.

Echeveria caespitosa DC. Prod. 3: 401. 1828.

Central California. Erroneously cited in original description as from Cape of Good Hope.

57. **Dudleya Helleri** Rose, sp. nov.

Caudex crowned by several (8 in specimens seen) small dense rosettes of leaves; basal leaves linear to ovate-linear, 3–4 cm. long, very glaucous, thickish, acute, 15 mm. wide at the base, 10 mm. wide or less just above the base; flowering branches slender, 10–15 cm. long, bright red, usually naked below (at least for 2–6 cm.), their leaves ovate, the upper ones short and acute; in-

florescence a rather small flat-topped cyme of 2–5 branches, each branch bearing 3–6 flowers; pedicels short, 2–5 mm. long; calyx-lobes ovate, acute; corolla deep yellow, less than 10 mm. long, the lobes united at base into a very short tube, broadly ovate, acute; stamens a little shorter than the corolla-lobes, attached almost at the base of the corolla.

Collected by A. A. Heller in Monterey Co. (exact locality not given), California, in July, 1903. Here seem also to belong specimens collected on Willow Creek, Santa Lucia Mountains, Monterey Co., California, by R. A. Plaskett, May, 1897 (no. 86).

58. DUDLEYA COTYLEDON (Jacq.) Britton & Rose.

Sedum Cotyledon Jacq. Eclog. 1: 27. *pl. 17.* 1811.

Cotyledon Californica Baker, in Saund. Refug. Bot. 1: *pl. 70.* 1869.

Echeveria Californica Baker, *l. c.* 1869.

Acaulescent, or very nearly so, tinged with red, basal leaves numerous, linear-lingulate, pale green, slightly glaucous, 6–10 cm. long, 2 cm. wide or less, sharply acuminate, the base widened; flowering branches stout, 4–5 dm. long, erect-ascending, glaucous, their leaves numerous, ovate to triangular-ovate, sagittate, half-clasping, acute, the lower ones about 2 cm. long, the upper gradually smaller, the similar bracts of the inflorescence 5 mm. long or less; inflorescence cymose-paniculate, 2.5 dm. long or less; pedicels stout, 4–10 mm. long; calyx white farinose, its lobes triangular-ovate, acute, 3 mm. long; corolla yellow, 1 cm. long, its tube slighter shorter than the calyx, its oblong-lanceolate segments acute, slightly keeled.

Monterey, California. The plates of Jacquin and of Baker clearly represent the same species, and this has recently been collected by Mr. L. R. Abrams at Monterey and flowered freely at New York Botanical Garden.

59. **Dudleya elongata** Rose, sp. nov.

Stems elongated, at length 2–4 dm. long, simple or branched; leaves nearly linear, broadest near the base, very glaucous, 4–8 cm. long, 9 mm. wide or less, acute to acuminate; flowering stems leafless below, leafy above, the leaves ovate, acute, cordate, 1 cm. long or less; inflorescence cymose-paniculate; pedicels very short, 1–2 mm. long; calyx-lobes ovate, acute, 4 mm. long, twice as long as the tube; corolla 12 mm. long, at first reddish yellow, in age deep red.

Near San Pedro, California, H. E. Hasse.

GORMANIA Britton, gen. nov.

Low, *Sedum*-like species, perennial by horizontal rootstocks. Leaves spatulate to obovate or nearly orbicular, those of the flowering stems similar to the basal ones, but smaller. Flowers cymose or thyrsoid, yellow to red. Calyx mostly deeply 5-lobed, the lobes acute or obtuse. Petals 5, united below the middle, acute to acuminate, somewhat spreading above. Stamens 10, borne on the corolla; anthers mostly oblong. Carpels many-seeded, united below, erect or nearly so, even in fruit.

Named for Mr. M. W. Gorman, of Portland, Oregon, an assiduous collector.

Type species, *Cotyledon Oregonensis* S. Wats.

1. Gormania Watsoni Britton.

Cotyledon Oregonensis S. Wats. Proc. Am. Acad. 17: 373. 1882. Not *Sedum Oreganum* Nutt. 1840.

Oregon.

2. **Gormania laxa** Britton, sp. nov.

Glabrous, green, about 3 dm. tall; flowering stems erect; leaves spatulate, about 2 cm. long, obtuse; inflorescence loose, cymose-paniculate, about 10 cm. broad and 16 cm. long, its branches lax, slender; pedicels 2–3 mm. long; calyx-lobes ovate-lanceolate, acute, 4–5 mm. long; corolla yellow (?), 10–11 mm. long, its lobes lanceolate, acute, united nearly to the middle; anthers about 2 mm. long; carpels erect, united at the base.

Waldo, Oregon, Thos. Howell, June 4, 1884.

3. Gormania obtusata (A. Gray) Britton.

Sedum obtusatum A. Gray, Proc. Am. Acad. 7: 342. 1868.

Sierra Nevada of California.

4. **Gormania Hallii** Britton, sp. nov.

Spreading, matted, green, not glaucous, the flowering stems 8 cm. high or less; leaves spatulate to spatulate-obovate, 15 mm. long or less, 4–6 mm. wide, rounded or slightly retuse at the apex, a little concave on the upper surface, the upper ones similar, narrower; calyx about 3 mm. long, its lobes oblong-lanceolate, obtusish; corolla about 7 mm. long, bright yellow, its tube somewhat shorter than the calyx, its lobes oblong-lanceolate, obtusish; pedicels very slender, 2–8 mm. long; cyme little compound, thyrsoid, about 3 cm. broad, 3–5 cm. high.

Vicinity of Tuolumne meadows, in the Canadian zone, at 2800–3100 m. altitude, Yosemite National Park, California, H. M. Hall and E. B. Babcock, July, 1902, no. 3545.

5. **Gormania anomala** Britton, sp. nov.

Rootstock rather slender; flowering stems 7–10 cm. high; basal and lower leaves spatulate, about 1.5 cm. long, the upper much smaller; cyme dense, 5 cm. broad or less; pedicels 2 mm. long, or those of central flowers 5–6 mm. long; calyx-segments ovate-lanceolate, acute; corolla yellow, 6–7 mm. long, its lobes lanceolate, acute, united by their bases to the length of about 0.5 mm.; carpels nearly erect, their filiform tips half as long as body.

Southern California. Type locality, sandy hills in path of strong daily sea-winds, San Luis Obispo County, Mrs. R. W. Summers, June, 1883.

6. GORMANIA DEBILIS (S. Wats.) Britton.

Sedum debile S. Wats. Bot. King's Exp. 102. 1871.

Utah, Nevada, Idaho and eastern Oregon.

7. GORMANIA OREGANA (Nutt.) Britton.

Sedum Oreganum Nutt.; T. & G. Fl. N. Am. 1: 559. 1840.

Glabrous, green; rootstock slender, creeping; flowering stems slender, erect or ascending, 8–15 cm. high; leaves spatulate-cuneate, obtuse or rounded at the apex, the lower 1.7 cm. long or less, the upper much smaller; cyme compound, 2–8 cm. broad; pedicels very short, mostly shorter than the calyx; calyx-lobes lanceolate to ovate-lanceolate, acute; corolla 8–10 mm. long, yellow, its linear-lanceolate long-acuminate segments united for about one fifth their length, much exceeding the stamens.

Alaska to northern California. Corolla said to be pale rose-color in original description, apparently erroneously, unless it fades to that tint.

8. **Gormania Burnhami** Britton, sp. nov.

Rootstock horizontal, rather slender; basal leaves spatulate to obovate-cuneate, thick, somewhat glaucous, retuse or obcordate, 1–2 cm. long, 1 cm. wide or less, those of the flowering stems similar, smaller; flowering stems 15 cm. high or less, rather stout, reddish; inflorescence thyrsoid, 6–10 cm. long, about 5 cm. wide, rather loose; pedicels stout, 3–6 mm. long, mostly shorter than the linear bracts; calyx 4–6 mm. long, its ovate or ovate-lanceolate lobes acute or acuminate; corolla cream-color, tinged with rose, about 1 cm. long, its segments oblong-lanceolate, acute, united for about one fourth their length.

Between Lake Eleanor and Lake Vernon, Tuolumne County, California, S. H. Burnham, July 16, 1894 (type); Cañon Creek, Trinity County, California, Alice Eastwood, July 2–18, 1901.

9. **Gormania retusa** Rose, sp. nov.

Rootstock rather thick; flowering stems 1–1.5 dm. tall; leaves obovate to spatulate, relatively thin, retuse, 2 cm. long or less, the upper much smaller; inflorescence dense, thyrsoid-cymose, about 6 cm. long; pedicels 3 mm. long or less; calyx-lobes ovate, acute, 3 mm. long; corolla pink or red, 6–7 mm. long, its segments oblong-lanceolate, acutish, united for about one fourth their length.

Sanhedrin Mountains, Lake County, California, alt. 1,500 meters, A. A. Heller, August 6, 1902.

10. **Gormania Eastwoodiae** Britton, sp. nov.

Rootstocks stout, horizontal; basal leaves spatulate, thick, obtuse, 1–2 cm. long, 1 cm. wide or less, rather pale green, slightly glaucous, those of the flowering stems similar, smaller; flowering stems 10–15 cm. high; cyme dense, 5 cm. broad or less; pedicels 2–5 mm. long; calyx about 3 mm. long, its triangular-ovate acute lobes about twice as long as the tube; corolla red or dark pink, about 7 mm. long, its segments oblong-lanceolate, sharply acute, united for about one third their length.

Red Mountain, northern Mendocino County, California, Alice Eastwood.

ALTAMIRANOA Rose, gen. nov.

Perennial, low, much branched species, often shrubby at base, with much more the habit of *Sedum* than of *Echeveria*, but petals not distinct, flowers purplish or white, rarely yellow, much smaller than in *Echeveria*. Sepals 5, linear, distinct. Corolla not angled, with a distinct tube, campanulate; the lobes broad and spreading. Stamens 10, borne on the corolla-tube. Carpels 5, erect.

Named in honor of Dr. Fernando Altamirano, who, as the Director of the Instituto Medico Nacional, is doing much to develop the scientific resources of Mexico.

Type species, *Cotyledon Batesii* Hemsl.

I have grouped together here certain anomalous species which have heretofore been resting in *Cotyledon* but with the habit of a *Sedum*, or in *Sedum*, but with united petals. It is possible that the species here brought together may not all be congeneric. It seems clear, however, that they should be taken out of *Cotyledon* and *Sedum*.

Altamiranoa elongata Rose, sp. nov.

Perennial, at first with slender erect branches, but rather weak and becoming prostrate, striking root at every joint, finely puberulent; leaves small, closely set at right angles to the branches, appearing imbricate in dried specimens, linear-ovate, acute, puberulent, 6 mm. long, turgid but somewhat flattened, with a cordate some-

what clasping base; inflorescence paniculate, its ultimate branches secund, bearing a few sessile flowers; sepals linear, 2 mm. long, puberulent; corolla white or pinkish, 5 mm. long, campanulate, its segments united at base into a short tube; carpels distinct.

A common species on the mountains above Pachuca, altitude about 2,850 meters. Collected by J. N. Rose, June 1, 1899 (no. 4461, type), and later in the same year by C. G. Pringle (no. 8233).

ALTAMIRANOA CALCICOLA (Robinson & Greenman) Rose.

Sedum calcicola Robinson & Greenman, Am. Jour. Sci. **50**: 150. 1895.

Las Cuavas, San Luis Potosi, Mexico.

ALTAMIRANOA PARVA (Hemsl.) Rose.

Sedum parvum Hemsl. Diag. Pl. Nov. 3: 51. 1880.

Only known from the type locality, which is near the City of San Luis Potosi, Mexico.

Altamiranoa Goldmani Rose, sp. nov.

A low much branched *Sedum*-like plant, glabrous throughout, with tuberous-thickened roots; old stems somewhat woody, procumbent and rooting at the joints, bearing scattered rosettes of leaves; flowering branches more elongated, 5–6 cm. long, rose-colored, bearing many rather closely set leaves; leaves very narrow, linear or nearly so, 10–12 mm. long, flattened, obtuse; inflorescence a very compact few-flowered cyme; flowers sessile; sepals distinct, linear, fleshy but flattened, obtuse, appressed to the corolla, unequal, 4–6 mm. long, reddish tinged; corolla 6 mm. long, not at all 5-angled, very thin when dry, pale yellow, tinged with red, orange colored when dry, its tube a little longer than the lobes; lobes ovate, acute, spreading; stamens 10, all borne at the top of the corolla-tube; scales small, purplish, 0.3 mm. long, about as broad as high, retuse at apex; carpels 5, distinct, oblong, reddish near tip, many-seeded; styles short.

Described from living specimens collected by E. A. Goldman among crevices of the rocks on the summit of Cerro de Patamban, Michoacan, Mexico, altitude 3,600 meters. The species has much the habit of *A. elongata*.

ALTAMIRANOA BATESII (Hemsl.) Rose.

Cotyledon Batesii Hemsl. Diag. Pl. Nov. 1: 9. 1878.

Central Mexico.

Altamiranoa scopulina Rose, sp. nov.

Glabrous throughout; stems more or less creeping and much branched, the lower parts covered with whitish scales (bases of old dead leaves); leaves linear, nearly terete, 4–6 mm. long, sessile and

with a free projection down the stem, closely set but hardly imbricate; flowers few, near the tops of the branches, sessile or short-pediceled; sepals leaf-like, shorter than the petals, somewhat unequal; corolla-segments pure white, oblong, acute, 5 mm. long, slightly united at base, nearly flat; appendages minute; stamens shorter than the corolla.

Collected by J. N. Rose on dry rocky hills near Tepeaca, south of Puebla, June 27, 1899 (no. 4996). Living specimens were sent to the Washington Botanical Garden and flowered in the open, June, 1900. From these the above description is drawn.

ALTAMIRANOA FUSCA (Hemsl.) Rose.

Sedum fuscum Hemsl. Biol. Centr. Am. Bot. 1 : 395. 1880.

Described as an annual but perhaps a biennial or possibly a perennial, diffusely branching, 1 dm. high or less; leaves broadly oblong, fleshy, 4–6 mm. long, obtuse; inflorescence cymose; pedicels 2 mm. long or less; sepals distinct, free at base; corolla-segments white, united for one fourth their length.

Only known from the region about San Luis Potosi, Mexico.

ALTAMIRANOA CHIHUAHUENSIS (S. Wats.) Rose.

Sedum Chihuahuense S. Wats. Proc. Am. Acad. 23: 273. 1888.

Described as annual but producing small tubers, simple below, branching above, 7–15 cm. tall; leaves sessile, oblong or oblong-lanceolate, obtuse, 2–3 mm. long; corolla-segments white, united at base, oblanceolate, 4 mm. long; carpels divergent above.

Rocky ledges, Sierra Madre of Chihuahua, Mexico. A very peculiar species and not well understood.

STYLOPHYLLUM Britton & Rose, gen. nov.

Perennials with more or less branched rootstocks; basal leaves linear, elongated, terete, or flattened but always narrow, sometimes abruptly widened below into a broad clasping base; flowering stems with long sessile leaves not clasping at base. Calyx 5-lobed, the lobes ovate, equal and small. Corolla campanulate, not angled, white, red or yellowish, its lobes broad, thin and spreading, united below into a tube. Stamens 10, borne on the corolla-tube. Carpels 5, united below, generally strongly spreading as in *Sedum*.

The type species, *Cotyledon edulis* Nutt., has been referred to both *Sedum* and *Cotyledon*. The name is in allusion to the pencil-shaped leaves of the type species.

1. STYLOPHYLLUM VISCIDUM (S. Wats.) Britton & Rose.

Cotyledon viscida S. Wats. Proc. Am. Acad. 17: 372. 1882. Southern California.

2. **Stylophyllum virens** Rose, sp. nov.

The thick and elongated branched stem sprawling over rocks, the lower parts clothed with old leaves, the ends crowned by dense rosettes of bright green leaves; leaves spreading or often reflexed, shining, not glaucous, 5–9 cm. long, gradually tapering from the base and there 10–15 mm. broad, fleshy but flattened throughout; inflorescence a weak many-branched panicle; calyx-lobes ovate, somewhat acutish in living specimens; corolla reddish, campanulate; carpels spreading.

Collected by Blanche Trask on San Clemente Island, California, June, 1903.

3. **Stylophyllum albidum** Rose, sp. nov.

Basal leaves in dense rosette, strap-shaped, widest at base, gradually tapering at the apex, very glaucous, 4 cm. long, 1 cm. broad at base, very thick, the upper one third terete; flowering stems reddish, 2–3 dm. long, their leaves narrow, somewhat acuminate; inflorescence a somewhat flattened cyme; pedicels very stout and short, 2–4 mm. long; calyx-lobes ovate, obtuse, very short, 2 mm. long; corolla 7 mm. long, reddish, its lobes lanceolate, acute, its tube 2 mm. long; stamens all borne at the top of tube, shorter than the corolla; carpels somewhat spreading above and united at base.

San Clemente Island, California, T. S. Brandegee, August 25, 1894 (type). Also collected on the same island by Blanche Trask in 1903.

4. **Stylophyllum Traskae** Rose, sp. nov.

Caudex thick and woody; leaves forming a dense rosette, strap-shaped, 4–5 cm. long, 8–10 mm. broad, glabrous, acute; flowering branches about 20 cm. long, reddish, with rather small scattered leaves; inflorescence a rather compact flat-topped cyme; pedicels short, 2–4 mm. long; calyx-lobes broadly ovate, acute or obtusish; corolla bright canary-yellow, 8 mm. long, the lobes somewhat spreading; carpels inclined to spread.

Only known from material collected by Blanche Trask on Santa Barbara Island off the coast of southern California, May, 1901. The plant was distributed as *Cotyledon lanceolata*, from which of course it is very distinct.

5. **Stylophyllum insulare** Rose, sp. nov.

Stems very thick and woody, 6–8 cm. in diameter, crowned by a rosette of spreading leaves, the old leaves somewhat persistent; leaves 10–15 cm. long, 1–1.5 cm. broad above the base, 2 cm. broad at base, fleshy, much flattened except toward the apex, acute, more or less glaucous especially when young; flowering branch stout,

purplish, 3–4 dm. long; inflorescence paniculately branched; primary branches short, nearly equal, two or three times dichotomous, the ultimate branches short and few-flowered; calyx 3 mm. long, its lobes twice as long as the tube, ovate, acute; corolla 7 mm. long, reddish, somewhat campanulate, its tube about the length of the carpels; carpels united at base, widely spreading.

Collected on Santa Catalina Island by Blanche Trask in May and June, 1897, and in June, 1902. The latter specimen, in U. S. National Herbarium, is the type.

6. **Stylophyllum Hassei** Rose, sp. nov.

Caudex elongated, sometimes about 3 dm. long, 2–3 cm. in diameter, somewhat branching, covered with the old persistent leaves, crowned with a dense erect rosette; leaves very glaucous, linear, not tapering, except toward the apex, 10 cm. long or less, 1 cm. wide or less, thick but flattened below, terete and obtuse toward apex; flowering stems weak, their primary branches 1–2-dichotomous, the ultimate branches slender and many-flowered; calyx small, glaucous, 4 mm. long, cleft to or below the middle, its lobes ovate, acute; corolla-tube about 1 mm. long; carpels widely spreading in age.

Collected on the sea beach on Santa Catalina Island by Dr. H. E. Hasse, May 30, 1902 (type), and on the same island by Blanche Trask, June, 1902.

7. **Stylophyllum semiteres** Rose, sp. nov.

At first acaulescent but old plants decidedly caulescent and branching; leaves numerous, closely set on the caudex, linear, semiterete, 10 cm. or so long, often becoming reddish, acute; flowering branches about 20 cm. long, their leaves ovate, turgid, acute, the lowest ones often opposite; inflorescence a pair of secund racemes; pedicels very short (1–3 mm. long); calyx 5 mm. long, its lobes 4 mm. long, ovate, acute; corolla 9 mm. long, its segments united below for about 2 mm., oblong, obtuse, yellowish but tinged with red; stamens borne on the corolla, all shorter than the corolla but those alternating with the lobes shorter than the others; carpels somewhat spreading.

Type from Lower California or the Colorado Desert of California sent by Mr. C. R. Orcutt, 1903.

In some respects these specimens correspond, especially in reference to the leaves, calyx, inflorescence and color of the flower, with Mr. Watson's description of *Cotyledon attenuata*, but they differ greatly from living specimens from type locality.

8. STYLOPHYLLUM EDULE (Nutt.) Britton & Rose.

Sedum edule Nutt. in T. & G. Fl. N. Am. **1**: 560. 1840.
Cotyledon edulis Brewer, Bot. Calif. **1**: 211. 1876.
Southern California, near the sea.

9. STYLOPHYLLUM ATTENUATUM (S. Wats.) Britton & Rose.

Cotyledon attenuata S. Wats. Proc. Am. Acad. **22**: 472. 1887.
San Quintin, Lower California.

10. STYLOPHYLLUM DENSIFLORUM Rose.

Cotyledon nudicaule Abrams, Bull. So. Cal. Acad. Sci. **2**: 42. 1903. Not Lam. 1786.

Plants growing in dense clumps with more or less branching rootstocks, very glaucous throughout; leaves numerous, erect, nearly terete, acute, 6–12 cm. long; flowering branches slender and weak; inflorescence a rather dense compact cyme, its ultimate branches rather short, 4–8-flowered; pedicels short, 1–3 mm. long; calyx 2 mm. long, its lobes twice as long as the tube, broadly ovate to orbicular, obtuse; corolla white or pinkish, 6 mm. long, its segments spreading, distinct nearly to the base; stamens 10, a little shorter than the corolla; carpels spreading.

Collected on mossy ledges and crevices of perpendicular cliffs, altitude 350 meters, in San Gabriel Cañon, Los Angeles Co., Cal., by H. E. Hasse, June 21, 1902, and at or near the same station by L. R. Abrams.

11. **Stylophyllum Orcuttii** Rose, sp. nov.

Resembling *S. attenuatum* in its foliage and habit, but stouter and very glaucous; corolla-tube much shorter and shorter even than the calyx, the lobes broader, and more keeled, segments rose-colored, not at all tinged with yellow; calyx-lobes obtusish; anthers red.

Collected on Coronado Islands by Lieut. Charles F. Pond, U. S. N., June 4, 1889; Initial Monument, C. R. Orcutt, R. D. Alderson, T. S. Brandegee (type) and in cultivation in various botanical gardens.

Mr. Orcutt says of this species: "First collected in 1883 by Miss Fanny E. Fisk, at Sanzal, on Todos Santos bay, Lower California; later found growing abundantly at the initial Mexican boundary monument, near San Diego, California, by C. R. Orcutt and others, and living material sparingly distributed as *C. attenuata*, from which it differs chiefly in its inflorescence. Corolla tinged with rose purple, not yellow as in *C. attenuata*. This and *C. attenuata* I cannot distinguish in cultivation except by the flowers,

both are glaucous or at length glabrous and bright apple-green." Recognized first by Dr. E. L. Greene as a new species, but not published by him.

Mr. Brandegee also recognized this as an undescribed species, and it is labelled as such in his private herbarium.

12. **Stylophyllum Parishii** Britton, sp. nov.

Stems not as thick as in *S. edule*, somewhat glaucous; flowering branches 2–3 dm. high, rather weak, glabrous; inflorescence paniculate; pedicels 8 mm. long or less; calyx 5-parted, the lobes 4 mm. long, broadly oblong with rounded apex; corolla-segments twice as long as the calyx, united at the base into a tube 2 mm. long, yellowish (?); stamens 10, borne on the corolla at the top of the tube; carpels united only near the base.

Pala, San Diego Co., Cal.; collected by S. B. and W. F. Parish, June, 1880 (no. 444).

HASSEANTHUS Rose, gen. nov.

Stems several, arising from small globose or oblong corms. Basal leaves linear, terete, narrowed below into flattened petioles; stem-leaves narrowly ovate, turgid but somewhat flattened. Calyx 5-lobed. Corolla-segments united at base into a short tube, yellow or white changing to purple. Carpels 5, united at base (?), widely spreading.

Named in honor of Dr. H. E. Hasse.

Type species, *Sedum variegatum* S. Wats.

1. HASSEANTHUS BLOCHMANAE (Eastw.) Rose.

Sedum Blochmanae Eastw. Proc. Cal. Acad. Sci. II. **6**: 422. *pl. 53*. 1896.

Along the road to Pt. Sal near Casmailia beach, Santa Barbara Co., California.

2. HASSEANTHUS VARIEGATUS (S. Wats.) Rose.

Sedum variegatum S. Wats. Proc. Am. Acad. **11**: 137. 1876.
San Diego Co., California.

3. **Hasseanthus elongatus** Rose, sp. nov.

Resembling *H. variegatus*, but with long slender stems and cyme-branches, linear elongated leaves, oblong calyx-lobes, and bright yellow corolla; the leaves not at all variegated.

Collected on the San Joaquin Hills, Orange Co., Cal., by L. R. Abrams, June, 1901 (no. 1785).

4. **Hasseanthus multicaulis** Rose, sp. nov.

Perennial by an oblong corm 2–3 cm. long. Stems 2–5, rather stout, 1–1.5 cm. high, variegated, glabrous, not at all glaucous; basal leaves 3–4 cm. long, terete, acute; stem-leaves 1–2.5 cm. long, ovate-oblong, acute or acuminate, turgid or somewhat flattened; inflorescence of several secund, many-flowered racemes; flowers subsessile; calyx-lobes ovate, obtuse; flower-buds pinkish, obtuse; corolla-segments widely spreading above the middle, pale yellow tinged with red, 7–8 mm. long, slightly united at base; stamens 10, borne on base of corolla-segments; carpels widely spreading (?) in age.

Known only from Los Angeles Co., Cal., where it has been collected by H. E. Hasse on sterile clay bluffs near Santa Monica, April, 1891 (type), May 11, 1891 (no. 5241), and May, 1902, at which time flowering specimens were sent to the writer.

It differs from *H. variegatus* in the shape of the corms, stouter and not glaucous stems, obtuse buds and subsessile flowers.

RHODIOLA L.

Perennials with a woody and somewhat branching rootstock. Leaves broad and comparatively thin. Flowers dioecious or polygamous, 4- or 5-parted. Corolla purplish, yellowish or greenish. Carpels erect. Style very short or none.

Type species, *R. rosea* L.

1. Rhodiola rosea L. Sp. Pl. 1035. 1753.

Sedum roseum Scop. Fl. Carn. Ed. 2, 326. 1772.

Sedum Rhodiola DC. Pl. Grasses, *pl. 143*. 1805.

Newfoundland and Greenland to Alaska, south to Maine; two isolated stations in eastern Pennsylvania. Also in Europe.

2. **Rhodiola Neomexicana** Britton, sp. nov.

Stems stout, very leafy, 1–2.5 dm. high; leaves linear-oblong, narrowed at both ends, entire, acute or obtusish, 2–3 cm. long, 3–7 mm. wide, or the lower proportionately shorter and broader and some of them serrulate; cyme terminal, dense, the staminate ones 2–3 cm. broad, the pistillate ones smaller; pedicels shorter than the petals or equalling them; petals linear-lanceolate, cucullate at the apex, longer than the linear calyx-segments; filaments one half longer than the petals.

On White Mountain Peak, Lincoln Co., New Mexico, at 3,500 meters, collected by E. O. Wooton, Aug. 1, 1901.

3. **Rhodiola Alaskana** Rose, sp. nov.

Resembling *R. integrifolia*, but usually taller and more slender (often 20 cm. high), usually quite pale and appearing glaucous in herbarium specimens; leaves oblanceolate, acute, 2–2.5 cm. long, strongly toothed in the upper third, drying very thin; petals purplish, obtuse; carpels 4–6 mm. long, gradually tapering into a slender style 1–1.5 mm. long.

Coast of southern Alaska. Type from Misty Harbor, Nagai Island, Alaska, C. H. Townsend, July 22, 1893.

4. RHODIOLA INTEGRIFOLIA Raf. Atl. Journ. **1**: 146. 1832.

Sedum rhodioloides Raf. *l. c.* 1832.

Sedum Rhodiola Torr. Ann. Lyc. N. Y. **2**: 206. 1827. Not DC. 1805.

Sedum frigidum Rydb. Bull. Torrey Club, **28**: 282. 1901.

High mountains of Colorado, Nevada and California to Alaska.

5. RHODIOLA POLYGAMA (Rydb.) Britton & Rose.

Sedum polygamum Rydb. Bull. Torrey Club, **28**: 283. 1901.

Mountains of Colorado.

6. RHODIOLA ROANENSIS Britton.

Sedum Roanense Britton; Small, Fl. So. U. S. 497. 1903.

Stems tufted, stout, leafy, 1.5–2.7 dm. high; leaves oblanceolate, entire, or rarely with a few minute teeth, obtusish or acute, narrowed at the base, 2–3 cm. long, 5–9 mm. wide, the lower much smaller and shorter; cymes dense, 2–3 cm. broad; flowers very short-pedicelled; petals lanceolate, purple, or purplish; follicles 8–10 mm. long, the short widely spreading beak about 1 mm. long.

On Roan Mountain, Mitchell Co., N. C. Type, collected by J. K. Small and A. A. Heller, July 16, 1891.

SEDUM L. Sp. Pl. 430. 1753.

Sedum muscoideum Rose, sp. nov.

Perennial, with branching creeping stems; leaves appressed, and closely set on the branches, minute, thickish, obtuse; inflorescence much reduced, consisting of 1 or 2 sessile flowers at the ends of the branches; calyx-lobes obtuse, ovate, 1 mm. long; corolla yellow; petals lanceolate, 3.5 mm. long, a little longer than the stamens.

Arriba de Papalo, Oaxaca, Conzatti & Gonzales, 1898 (no. 777).

Closely resembling *Sedum cupressoides*, but with yellow flowers. Mr. Hemsley has compared the material with his type of the latter species and agrees with me that it is different.

Sedum submontanum Rose, sp. nov.

Perennial, much branched and spreading, glabrous throughout; leaves very closely set or even imbricate, small, 3–5 mm. long, short-oblong, rounded at tip, free at base, fleshy; flowers few, in short-branched cymes, sessile; calyx-lobes leaf-like, short, 1–2 mm. long, rounded at apex; petals narrow, white (or if pink very pale), 5–6 mm. long; scales small, retuse at apex; carpels spreading above.

Collected by J. N. Rose on rockwork in public plaza at Monte Escobado, Zacatecas, August 27, 1897 (no. 2042, type), and by C. G. Pringle on banks and ledges, Sierra de las Cruces, Jalisco, August 12, 1893. This little plant was distributed as *S. Moranense* from which it differs in its more herbaceous calyx-lobes, and paler and larger flowers.

Sedum calcaratum Rose, sp. nov.

Perennial (?), much branched, 5–8 cm. high, glabrous, more or less purple; leaves linear, "cylindrical," obtuse, 10–12 mm. long, alternate and scattered; flowers arranged along one side of the branches, subsessile; calyx-lobes 5, somewhat unequal, 2–3 mm. long, green; stamens 10; scales linear, about two thirds the length of the filaments; petals red, 5 mm. long, obtuse; carpels 5, widely spreading when mature, with long mucronate tips.

Collected by C. G. Pringle on thin soil of limestone ledge near El Salto near Dublan, Hidalgo, Mexico, 1901 (no. 8620).

Sedum oxycoccoides Rose, sp. nov.

Perennial by creeping fleshy rootstocks, with many slender branches arising from the base, glabrous throughout; leaves numerous, linear, 8–15 mm. long; flowers in small few-branched cymes, sessile or sometimes short-pedicelled; calyx-segments linear, leaf-like, somewhat unequal, the longer ones as long as petals; petals deep red, lanceolate, acuminate, 10 mm. long, longer than the reddish stamens; carpels free to base, spreading.

Collected by J. N. Rose in deep shady ravines near Santa Teresa, Tepic, August 11, 1897 (no. 2198).

SEDUM MINIMUM Rose.

Sedum Pringlei minus Rob. & Sea. Proc. Am. Acad. **28**: 105. 1893. Not *S. minus* Haw. 1825.

Delicate perennial, about 2 cm. high, arising from small globose tubers; leaves oval-oblong, obtuse, 4 mm. long; calyx-lobes 3–3.5 mm. long, linear, free at base; petals distinct, violet (?), longer than the calyx; filaments 10, only 5 anther-bearing; scales linear, 0.6 mm. long, obtuse or retuse; carpels united for one third their length; styles very short.

Collected by C. G. Pringle on summit of the Nevada de Toluca, State of Mexico, September, 1892 (no. 4240).

Sedum Hemsleanum Rose, sp. nov.

Perennial, caulescent, 1–3 dm. high, branching, puberulent; basal leaves in small rosettes, orbicular; stem-leaves linear to lanceolate, 2 cm. long, obtuse, puberulent; inflorescence an elongated panicle; flowers sessile, arranged along one side of the axis; calyx-lobes broadly ovate, obtuse, 1.5 mm. long; petals white, 4 mm. long, ovate, acuminate; carpels 5, tipped with long slender styles.

Collected by F. Müller, Orizaba, (no. 322), by C. G. Pringle near Oaxaca City, November, 1894 (no. 6042, type), and by E. W. Nelson on rocks between Petlatcingo and Acatlan, Puebla, November, 1894 (no. 2001).

Sedum australe Rose, sp. nov.

Perennial, procumbent, rooting at the joints; branches woody, tuberculately roughened; leaves numerous, densely imbricate, terete, obtuse, 6–7 mm. long, glabrous; inflorescence a short compact cyme; calyx-lobes leaf-like, half as long as the petals; petals reddish-yellow, 7 mm. long, mucronate on the back below the apex; carpels widely spreading when mature.

Collected by E. W. Nelson on the volcano of Santa Maria, Guatemala, January 24, 1897 (no. 3707).

Sedum Shastense Britton, sp. nov.

Perennial by a slender rootstock, glabrous; stems slender, erect, or the base decumbent, 6–12 cm. high; leaves lanceolate to oblong-lanceolate, 10–15 mm. long, 3–5 mm. wide, acute, papillose, the narrowed base somewhat prolonged below the axil; cyme small, compact, 2–3 cm. broad; flowers few, sessile or nearly so; calyx-segments ovate to triangular-ovate, acute, about half as long as the petals; petals very thin, lanceolate, acuminate, yellow, strongly 1-nerved, about 8 mm. long, exceeding the stamens and pistils; styles subulate; young follicles erect.

North side of Mt. Shasta, Siskiyou County, California, H. E. Brown, July, 1897 (no. 441).

Sedum Cockerellii Britton, sp. nov.

Perennial, glabrous, branched, 2 dm. high or less; basal leaves not seen; stem-leaves lanceolate to oblong-lanceolate, sessile, acute, 1–2.5 cm. long, 6 mm. wide or less; cymes 2.6 cm. broad; flowers subsessile; calyx-segments nearly linear, acute or acutish, a little shorter than the petals; petals linear-lanceolate to linear-oblanceolate, acute, 6–8 mm. long, white; anthers pink; carpels erect; styles subulate.

Tuerto Mountain, east of Santa Fé, New Mexico, T. D. A. Cockerell, in 1895 (type); Mt. Carmel, on the Rio Grande, Parry (Mex. Bound. Surv., no. 403).

Sedum (?) guttatum Rose, sp. nov.

Much branched at base, shortly caulescent; leaves glabrous, opposite, 2 or 4 pairs, 2–3 cm. long, thickish, rounded on the back, broadly channeled on the face, sage-gray color, spotted with purple-black blotches, obtuse; inflorescence terminal, cymose; branches 2 or 3, spreading; pedicels very short; sepals free to the base, oblong, 3–4 mm. long, subequal, green, obtuse; petals narrowly oblong, 5 mm. long, obtuse, apparently reddish, free to the base; stamens 10, shorter than the petals, the 5 opposite the sepals free to the base, the other 5 borne on the petals; scales small, obtuse; carpels 5, distinct to the base, erect; styles about as long as the carpels, slightly spreading.

Common in the crevices of the most exposed rocks on summit of hill at Saltillo, Mexico. Collected by Dr. E. Palmer in 1902 (no. 309) and now in cultivation in Washington.

Sedum naviculare Rose, sp. nov.

Annual; stems simple or branching at base, glabrous, purplish, 5–10 cm. long; basal leaves not seen; stem-leaves scattered, "spatulate, concavo-convex," obtuse, glabrous, 2–10 mm. long; inflorescence of 2 or 3 more or less elongated, one-sided racemes; flowers scattered, subsessile or sometimes very distinctly pedicelled; sepals linear, nearly equal, green, 1.5–3 mm. long; petals free to the base, purplish, ovate-lanceolate, 4 mm. long, obtuse; stamens 10, all decidedly shorter than the petals, those opposite the petals attached to them above the base; anthers short, purple; scales 5, alternating with the sepals, very distinct, 0.6 mm. long, narrowly club-shaped; carpels erect, glabrous.

Collected by C. G. Pringle on the rocky knobs of Sierra de Tepoxtlan, Morelos, altitude 2,250 meters, October 13, 1900 (no. 8384).

Sedum Conzattii Rose, sp. nov.

More or less shrubby at base, 3–4 dm. high, branched, puberulent; leaves alternate, spatulate, rounded or retuse at apex, 2–3 cm. long, thin; inflorescence a short cyme; sepals about 2 mm. long, free to base; petals white or purplish, 6 mm. long, acute; stamens shorter than the petals; anthers reddish; scales very small.

Collected on Sierra de San Felipe, Oaxaca, by C. G. Pringle, October 11, 1894 (no. 4982), and by Professors Conzatti and Gonzalez, September 26, 1897 (no. 495, type). This species some-

what resembles and has been taken for *S. oxypetalum*, but it is of much more open growth, with lighter colored flowers. It must also be related to *S. tortuosum*.

Sedum nutans Rose, sp. nov.

Perennial, with a thick woody caudex; basal leaves forming a broad rosette, thickish, obovate, 4–7 cm. long, 2.5–3 cm. broad at widest point, glabrous; flowering stems about 1 dm. long, bearing small leaves; inflorescence a narrow panicle, 1 dm. long or less, the main branches reflexed; pedicels 3–4 mm. long; calyx deeply 5-parted, its lobes linear-oblong, somewhat unequal, 4–6 mm. long, rounded at apex; petals bright yellow, ovate, 6 mm. long, acute; stamens 10, free to the base; scales retuse; carpels erect.

Collected by C. G. Pringle on mossy cliffs of Tepoxtlan, Morelos, altitude 2,250 meters, February 8, 1899 (no. 6980).

Sedum Nelsoni Rose, sp. nov.

Caulescent, branching, especially above, 1–1.5 dm. high; branches brownish and tuberculately roughened; leaves (at least in herbarium specimens) thin and distinctly nerved, spatulate, 2.5–3.5 cm. long, 6–7 mm. broad at widest point, narrowed at base into a rather distinct petiole and extending below the point of insertion into a broad spur; inflorescence a few-flowered cyme; pedicels 4–5 mm. long; sepals distinct, unequal, the longer ones 8 mm. long; petals free (?) to the base, lanceolate, acute, yellowish but with a broad reddish stripe on the back; stamens opposite the petals borne high upon them, the others attached at or near their bases; carpels widely spreading from the very base.

Collected by E. W. Nelson on the road between Ayusinapa and Petatlan, Guerrero, Mexico, December 14, 1894 (no. 2191).

Resembling somewhat *S. confusum* Hemsl., but the flowers are not sessile.

Sedum (?) longipes Rose, sp. nov.

Stems slender, creeping, rooting at the joints; sterile branches bearing dense rosettes of small orbicular leaves; flowering branches seemingly erect, 2–3 cm. high, flowering toward the top; flowers solitary in the axils of the leaves, 8–10 mm. long; sepals ovate, obtuse, 2–3 mm. long; petals purple, 4–5 mm. long, lanceolate, apparently keeled near the tip; scales (for the genus very conspicuous) strongly 2-lobed, each lobe with several teeth at apex; stamens 10, shorter than the petals.

Collected by C. G. Pringle on the mossy ledges of conglomerate of the Sierra de Tepoxtlan, Morelos, February 8, 1899 (no. 8049).

16. **Sedum Wootoni** Britton, sp. nov.

Rootstocks rather stout; stems tufted, slender, erect or ascending, 1–1.5 dm. high, granular-puberulent above, glabrous below; cyme 2.5–5 cm. broad, its branches densely granular-puberulent; pedicels 2 mm. long or less; leaves sessile, 8–14 mm. long, 2.5–5 mm. wide, the basal and lower ones obovate to spatulate, obtuse, the upper narrowly spatulate to linear-oblong, acute to acuminate; sepals narrowly oblong, obtusish; petals white, oblanceolate, acute, longer than the sepals, 6–8 mm. long; carpels erect, subulate-tipped.

Organ Mountains, New Mexico, 2,000 m. altitude, E. O. Wooton, September 17, 1895.

Sedum Californicum Britton, sp. nov.

Rootstock rather stout, nearly horizontal; stems erect, stout, 1.5–2 dm. high; basal leaves and those of rosettes spatulate, obtuse, 1–3 cm. long, 8–10 mm. wide, the flabellately arranged veins uniting in an intramarginal nerve; stem-leaves linear-oblong to oblong-spatulate, acute to acutish, about 1 cm. long; cyme large, 6–10 cm. broad, its branches stout, ascending or somewhat recurved, mostly once or twice forked; flowers sessile or the lower ones on stout pedicels 3 mm. long or less; sepals ovate, acutish or obtuse, about 2 mm. long, one fourth to one third as long as the narrowly lanceolate, white, long-acuminate petals; carpels broad, divergent, finely reticulated, the subulate tips ascending.

North side of Mount Shasta, Siskiyou County, California, 1600–3,000 m. altitude, H. E. Brown, June 11–16, 1897 (no. 336).

Sedum Yosemitense Britton, sp. nov.

Perennial by rootstocks, very fleshy, stoloniferous; basal leaves obovate-orbicular to broadly obovate, 1 cm. long or less, 6–9 mm. wide, rounded at the apex, green, not glaucous, or scarcely so; flowering stems 1–1.5 dm. high, slender, their leaves spatulate-obovate to oblong, obtuse, small; cyme compound, 5 cm. broad or less, rather densely flowered; pedicels stout, 0.5–2.5 mm. long; calyx deeply cleft, its lobes ovate-lanceolate, acute or acutish; petals light yellow, lanceolate, acuminate, 6–8 mm. long, twice as long as the calyx or longer; follicles somewhat divergent, tipped with filiform styles.

Yosemite National Park, Cal. Type collected by H. M. Hall and E. B. Babcock, between Vernal and Nevada Falls, July, 1902 (no. 3425).

Sedum diversifolium Rose, sp. nov.

Sterile branches short, with small ovate flattened pale roughened leaves; flowering branches elongated, weak, glabrous, with scattered leaves; leaves 5–10 mm. long, turgid, somewhat curved

backward, pale green, smooth; flowers terminal, solitary, short-peduncled, inconspicuous; sepals 5, leaf-like, obtuse, 2–3 mm. long; petals pale yellow, twice the length of the sepals, ovate, acute, or even apiculate; stamens 10, much shorter than the petals.

Living specimens collected in state of Mexico by J. N. Rose (no. 248), and flowered in greenhouses of Department of Agriculture, and of New York Botanical Garden, December, 1901.

SEDELLA Britton & Rose, gen. nov.

Diminutive Californian annuals, with small ovate to ovate-oblong leaves and small yellow cymose flowers. Calyx with 5 very small, triangular acute teeth. Petals linear to ovate-lanceolate, united at the base, spreading (?) Stamens 10. Carpels oblong, 1-seeded, the seed erect.

Type species, *Sedum pumilum* Benth.

1. Sedella pumila (Benth.) Britton & Rose.

Sedum pumilum Benth. Pl. Hartw. 310. 1849.
California.

2. Sedella Congdoni (Eastw.) Britton & Rose.

Sedum Congdoni Eastw. Proc. Cal. Acad. III. 1: 135. *pl. 11.* 1898.
Grant's Springs, Mariposa County, California.

The Flora of the Matawan Formation (Crosswicks Clays).

By Edward W. Berry.

Introduction.

Some of the earliest of American geological writings refer to the New Jersey Cretaceous, and the accessibility of this area has ever since made it a favorite field for investigation. Interest for a long time centered about the marl deposits and those of the plastic clays because of their economic importance; the present Matawan formation was included in the "plastic clay and sand formation" of the geologists of the first half of the nineteenth century, and their stratigraphic position was considered to be Lower Cretaceous by Rogers in his first report published in 1840, although they were not clearly

defined by him. Professor Cook from 1863 until his death in 1889 published annual reports as state geologist of New Jersey and early subdivided the Cretaceous into the three marl beds, the clay-marls and the plastic clays. The Cretaceous was extensively summarized and described by him in the Geology of New Jersey, published in 1868, the clay-marls being divided into a lower member of clay containing green-sand and an upper member consisting of laminated sands The thickness of the formation was placed at 277 feet, 170 feet for the upper, and 107 feet for the lower member, and over a dozen localities were enumerated where the clay-marls were dug as fertilizer. In 1891 Professor William Bullock Clark commenced a study of the coastal series of New Jersey which has been in progress ever since. Three official reports have been published: a Preliminary Report,* a Report of Progress,† and a Final Report;‡ besides numerous other papers from which many of the following facts in regard to the areal distribution and thickness of the Matawan formation have been quoted.

The name Clay-marls was proposed by Cook; his characterization was incomplete, however, and was confined almost entirely to their development in northern New Jersey. This name does not adequately designate the formation lithologically and has been superseded by the name Matawan formation of Clark.§ The Matawan is separated from the Piedmont plateau by a tract of Raritan, or Lower Cretaceous, which is some ten to fifteen miles wide. The Matawan is nine to twelve miles wide in Monmouth county, becoming narrower to the southward, being reduced to about six miles in width in southern New Jersey; on the western shore of the Delaware river in Delaware it is further reduced to from two to three miles; further south on the eastern shore of Maryland it broadens, being about five miles wide

*Ann. Rep. State Geol. N. J. 1892: 167–245. 1893. (Clay-marls, pp. 186–190.)

†Ann. Rep. State Geol. N. J. 1893: 329–355. 1894.

‡Ann. Rep. State Geol. N. J. 1897: 161–210. 1898.

§Jour. Geol. 2: 163. 1894.

below the Sassafras river; on the western shore in Anne Arundel county the areal distribution is variable on account of the broken character of the country, but is on the whole narrower; further south, in Prince George county, it forms but a narrow strip less than a mile in width.

The materials are variable; sands and clays predominate. The sands are sometimes white and coarse, but more commonly fine-grained and colored by iron, even causing local induration, or they may be mixed with argillaceous materials forming silvery micaceous sand, or chocolate-colored marl, glauconite grains being present in greater or less amounts. The clays are generally black or drab, locally carrying seams and pockets of glauconite; occasionally they are calcareous as a result of their molluscan contents.

The thickness is variable, but becomes reduced to the southward. It increases considerably to the southeast, judging from the well records.* In northern Burlington county the Matawan is less than 200 feet thick; east of Philadelphia and Camden it is 125 feet; in Gloucester county it is 175 feet in places; in Salem county it is 80 feet; in Delaware not over 60 feet; near the mouth of the Sassafras river in Maryland it is 100 feet; in eastern Anne Arundel county it is 60 feet; in western Anne Arundel county and Prince George county it is thinner, until at Fort Washington bluffs it is a little more than 15 feet. Its farthest known southern appearance is in the valley of Piscataway creek; on the opposite shore of the Potomac the Eocene rests directly on the Potomac formation.

Long thought to conformably overlie the Raritan, an unconformity is now known to exist, although the time interval was not very great. Along Raritan Bay in the vicinity of Cheesequake creek where the upper Raritan contains dark-colored clays, the interbedded sands and clays gradually grade from Raritan into the Matawan. Further inland and to the southward the interval was greater since the Matawan gradually transgresses the Raritan and comes to rest, in cen-

* Woolman, Ann. Rep. State Geol. N. J. 1895: 63–95. 1896.

tral and southern Maryland, upon the lower members of the Potomac group which are not represented in New Jersey. Elsewhere in New Jersey the upper Raritan consists of white sands or fine gravel and the line of contact is sharp, except where it is obscured by Tertiary or later deposits. The Matawan is conformably overlain by the lower Monmouth formation; the lithological differences are clearly marked, however.

In its northern portion the Matawan is readily separable upon lithological grounds into Crosswicks Clays and Hazlet Sands; outside of New Jersey in Delaware and Maryland these divisions cannot be recognized with any certainty. The Crosswicks Clays consist of slate or drab-colored clays with thin seams and pockets of glauconite, becoming dark, almost black, locally interstratified with white sand, containing much lignite and beds of leaves on Raritan Bay. The lignified trunk of a large tree was found in the clays in this vicinity, as well as many fragments. Further southward the clays become brittle, more arenaceous and micaceous and contain less iron sulphide. The Hazlet Sands are highly ferruginous, brown in color, with indurated crusts in their lower layers; above these there is frequently a well-developed layer of dark-colored clay, overlain with very micaceous sands, which are sometimes dark-colored, especially toward the south where they are also argillaceous.

In his report on surface geology Professor R. D. Salisbury states * that his assistant, Mr. G. N. Knapp, distinguished five layers in the clay-marls and traced them across the state. These he designates Merchantville bed (marly clay), Woodbury bed (dove-colored clay), Columbus bed (sand), Marshalltown bed (marly-clay sand), and Wenonah bed (sand). These features, although more or less marked, are not sharply defined throughout the entire area of the Matawan, and Professor Clark has never attempted to name or map any subdivisions other than the lower clay member and the upper sandy member.

The Matawan is abundantly fossiliferous, especially along

* Ann. Rep. State Geol. N. J. 1898: 35. 1899.

Crosswicks and Pensauken creeks. Clark enumerates 86 species of invertebrates, mostly molluscs, and Lewis Woolman in his artesian well reports has added several others, as has also Mr. C. W. Johnson,* who points out their identity with the Ripley fauna of the Gulf region. Other remains include sharks' teeth; Foraminifera, of which 20 species are recorded by Bagg; † echinus and other spines; Ostracoda; gavial (?) teeth; dinosaurian bones; ‡ etc.

The exposure fronting on Raritan Bay near Cliffwood, N. J., and forming a bluff some thirty feet high northwest of Matawan creek, has been admirably described by Hollick,§ who records obscure crustacean and molluscan remains, from which Professor Whitfield identified eight species of molluscs, and enumerates twenty-six species of plants, of which ten were new. I have found some few molluscan remains here, occurring in the ferruginous concretions picked up on the beach, from which Professor Clark has identified the following: *Idonearca vulgaris* Morton, *Veleda lintea* Conrad, *Cardium* sp., *Turritella vertebroides* Morton and one or two other species, new to the formation, not yet thoroughly studied.

I have nothing to add to the details of the exposure. It is capped with gravel and in places consists of regularly alternating beds of fine sand several inches thick and seams of comminuted vegetable matter an inch or two in thickness (*pl. 56*). These are replaced by alternating beds of clay and sand with lignite, and sparingly with greensand. The face of the bluff is almost entirely hidden as shown in *pl. 55*, and while the majority of my plant remains have been collected from dropped boulders of clay, all have come from near the base of the exposure except the large cone (*Sequoia* sp.). These plant beds are some distance above the base of the formation, however, and their preserva-

* New Cretaceous Fossils from an Artesian Well-boring at Mount Laurel, N. J. Proc. Phila. Acad. 1898: 461–464. 1898.

† U. S. Geol. Surv. Bull. 88, 1898.

‡ Ann. Rep. State Geol. N. J. 1896 : 248. 1897.

§ Trans. N. Y. Acad. Sci. 16: 124–136. *pl. 11–14.* 1897.

tion is due in a large measure to the character of the materials, as vegetable remains are abundant in the form of lignite, forming thin seams intercalated in the sands nearly to the top of the exposure. The various layers are not continuous for any distance along the bluff and evidently indicate an inshore shallow fresh-water deposit which as time progressed gradually became marine through encroachments of the sea; the upper layers of sand with thin seams of comminuted vegetable matter indicating changed conditions and deposits in less quiet waters.

It is quite evident that sufficient material has not yet been accumulated to warrant an exhaustive discussion of the flora. I am enabled to enumerate sixty-seven different species of plants of which fourteen are new; of these sixty-seven species some nineteen are of doubtful affinities, such as the various species of *Carpolithus*, *Arisaema*, *Podozamites*, *Phragmites*, and the various fragments provisionally determined. There are present, however, in great abundance, such characteristic mid-Cretaceous forms as *Dammara*, *Cunninghamites*, *Dewalquea*, *Moriconia*, *Salix flexuosa*, *Proteoides daphnogeneoides*, *Sassafras acutilobum*, *Laurus plutonia*, *Sapindus Morrisoni*, *Andromeda Parlatorii*, etc.

The flora has more in common with the middle (Woodbridge) stage of the Raritan than with the other layers of that formation, eleven of the seventeen identical species occurring there, but this is undoubtedly due to the fact that this horizon is the best known; the upper Raritan (South Amboy) layers have not been sufficiently exploited to give us a clear idea of the vegetation prevalent when they were deposited. Forty-nine of the Matawan species have not as yet been found in the Raritan, although two of these are found on Long or Staten Island in beds probably of Raritan age. While this comparison might argue a considerable interval between the two formations, it remains to be pointed out that the following ten species are confined to the Raritan of New Jersey or the Islands and the Matawan formations on this continent: *Chondrites flexuosus*, *Geinitzia formosa*, *Cunning-*

hamites elegans, *Moriconia cyclotoxon*, *Magnolia Woodbridgensis*, *Laurophyllum angustifolium*, *Aralia palmata*, *Ficus Woolsoni*, *Paliurus integrifolius* and *Celastrophyllum Newberryanum*, and all except possibly *Paliurus* and *Chondrites* with well-characterized remains. Of the numerous species which are identical with those of the Dakota group of the West only eight are confined to the Dakota and Matawan formations. There are twenty-three species identical with Dakota group forms, but it may be remarked that the latter horizon is not precisely defined and its flora is exceptionally well known.

Fifteen of the Matawan species are found in the Raritan Cretaceous of the islands; nine occurring on Staten Island, eight on Long Island, seven on Martha's Vineyard, and four on Block Island. Eleven of the Matawan species reappear in the Atane beds of Greenland, and one additional in the Patoot beds; of these several are dominant forms of great vertical or areal distribution, or both, and thus have little significance; such forms are *Sequoia Reichenbachi*, *Sapindus Morrisoni*, *Laurus plutonia* and *Andromeda Parlatorii*. Others are more suggestive; thus, exclusive of its occurrence in the clays at Aachen, *Moriconia* is confined to the ancient Atlantic coastal plain and Greenland, and its remains are common; several species of *Magnolia* emphasize the similarity of these floras, as does the presence of the large-leaved *Aralia Ravniana*. This species is confined to the Atane and Matawan floras in so far as I can judge from the published descriptions or figures of Aralias, and its remains are unmistakably characterized. *Dewalquea Groenlandica* is also confined to these floras. With the Potomac flora as elaborated by Fontaine there seems to be no affinity, and the time that elapsed between them must have been very long.

Of species which occur in the Cenomanian of Europe we have *Geinitzia formosa*, *Sequoia Reichenbachi*, *Cunninghamites squamosus*, *Cunninghamites elegans*, *Moriconia cyclotoxon*, *Sassafras acutilobum*, *Laurus plutonia*, *Banksia pusilla*, *Sapindus apiculatus* and *Eucalyptus Geinitzi*, a

total of ten species or over 15 per cent.; or, on excluding doubtful species such as those of *Banksia*, *Eucalyptus* and *Sapindus*, and such wide ranging forms as *Sequoia Reichenbachi*, over 9 per cent.

The most striking feature about the Matawan flora is the entire absence of ferns, which form 5½ per cent. of the Raritan flora, *Anemia stricta* being commonly found at Woodbridge. Ferns form 1⅓ per cent. of the Dakota flora, 11 per cent. of the Atane flora, and about 2 per cent. of the existing New Jersey flora. In the most recent southern flora with which the Matawan may be compared, that of Alabama,* sixty-two species of Pteridophytes are listed forming about 2½ per cent., and this percentage would be greatly increased if we excluded herbaceous plants, which as a rule do not occur as fossils. It is difficult to account for the absence of this order, as the balance of the flora is proportionally normal, containing nearly 11 per cent. of Coniferae against 11⅙ per cent. in the Raritan and 10 per cent. in the Atane beds. Presumably the environment was unsuited to ferns, although, of course, future discovery may disclose them. Judging by such forms as *Dammara*, *Araucarites*, *Eucalyptus*, *Sterculia*, *Aralia*, *Myrsine*, *Ficus*, etc., we may infer that the climate was considerably warmer than at the present day in this latitude, and at least sufficiently humid to make the absence of ferns remarkable. A palm (*Serenopsis*) occurs at Glen Cove, Long Island,† and the Raritan furnishes many additional representatives of genera which are exclusively tropical at the present time, as for instance *Cinnamomum*, *Bauhinia*, etc.

Plants especially abundant in the Raritan formation and for which we have repeatedly searched in the Matawan are *Thinnfeldia subintegrifolia* (Lesq.) Knowlton, *Tricarpellites striatum* Newb., and *Tricalycites papyraceus* Newb. The genera *Myrica* (7 sp.) and *Liriodendron*, (4 sp.) which are abundantly developed in the Raritan, and on the islands, have

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* Mohr, Plant Life of Alabama. Contr. U. S. Nat. Herb. v. 6. Jl 1901.

† Dr. Hollick writes that material recently collected may result in altering his views as to the botanical affinity of these remains.

thus far been found wanting. Other Raritan genera which do not appear in the Matawan formation are *Menispermites*, *Diospyros*, *Cissites*, *Ilex*, *Cinnamomum*, *Dalbergia*, *Bauhinia*, *Colutea*, *Planera*, *Viburnum*, *Juglans*, etc.; several of these occur in the upper layers of the Raritan, and future search ought to disclose some of them in the Matawan. *Celastrophyllum* with abundant remains of ten species in the Raritan (all horizons) has but two species in the Matawan, one of these being new and unrelated to any of the known Raritan species. *Widdringtonites* is abundant in the Raritan as are also *Salix inaequalis* and *Hedera primordialis*; *Myrsine borealis* Heer is one of the commonest leaves at all localities in the Raritan, as *Sequoia heterophylla* Vel. is one of its commonest conifers. *Celastrus arctica* is abundant at South Amboy, and should extend up into the Matawan. Numerous specimens of *Ophioglossum granulatum* are also found in the Raritan according to Newberry (localities not given). The genus *Aralia*, so abundantly represented in the Raritan, continued to develop during Matawan time. We record six species, the large-leaved *Aralia Ravniana* emphasizing the similarity of these Atlantic coastal Cretaceous floras with those of Greenland. It is of course quite possible, indeed it seems probable, that these numerous species of *Aralia* may for the most part be the variable leaves of a considerably less number of actual species; especially is this so of the Raritan species.

This is the extreme northeastern extension of the Matawan, and the only locality where plant remains have been found, although the underlying Raritan continues northeastward as far as Buzzard's Bay and doubtfully on Cape Cod. This northeastern extension has been much modified by forces which acted upon it during the Quaternary age and is for the most part entirely covered with drift or totally eroded, and if the Matawan formerly extended so far north and east this has been its fate. Professor Lester F. Ward* proposed the name Island series for the northeastern extension of the Raritan and makes it the uppermost member of the Potomac,

* Ann. Rep. U. S. Geol. Surv. 15 : 335, 336. 1895.

unrepresented in New Jersey. Hollick would consider it the equivalent of the New Jersey Raritan, its distinctive characters being due to morainal action, with which view I entirely concur.

From the evidence of the flora alone we would consider the Matawan slightly more recent than the Raritan; a direct continuation of the latter, however, with several species added which are unknown from the Raritan. Thus, aside from the dissimilar species due to our imperfect knowledge of the flora of the two formations it remains to be pointed out that the occurrence of *Nelumbo* argues a somewhat later age for the Matawan, as this genus is not found below the Belly River Cretaceous on this continent.* Time must also have elapsed for the development or introduction of the various species of *Sterculia* which are found here as well as for the changed species of *Aralia*. The scarcity (absence) of ferns, the absence of *Brachyphyllum* which is essentially a Lower Cretaceous genus, and the much larger leaved *Moriconia* all point to a somewhat later time than the Raritan.

The Matawan, then, represents the transition period from the Lower to the Upper Cretaceous, when marine conditions replaced fresh-water estuarine conditions; and the flora is undoubtedly the latest Cretaceous flora of the Atlantic coastal plain which has been preserved. Professor Ward suggests that this ancient coastal plain may have extended to Greenland, but no evidence other than the remarkable similarity of the floras is known.

Just a word in regard to the remains. In common with the vast majority of New Jersey Clay specimens, the Matawan plants were hermetically sealed in the clay and slowly carbonized, so that when reëxposed to the air, the thick sheet of lignite dries, becoming cracked, and is soon dissipated, leaving only a faint impression behind. This has for years proved an obstacle to the proper investigation of these floras and it is only with the discovery of leaf-layers carrying con-

* Dr. Hollick has found *Nelumbo* on Martha's Vineyard and Long Island, the latter locality as yet unpublished, which vitiates the above statement.

			C. A. White.*	W. B. Clark.†	L. F. Ward.‡			W. B. Clark.§			
Atlantic Coastal Plain	Tertiary	Marine	Upper Marl Bed	Manasquan				Eocene	Shark River		Old upper marl bed.
	Cretaceous							Upper Cretaceous	Manasquan		
			Middle Marls	Rancocas					Rancocas	Vincentown limesands Sewell marls	Middle Marls.
				Red Bank					Monmouth	Redbank Sands Navesink Marls Mt. Laurel Sands	Redsands and Lower Marl Bed.
			Lower Marls	Navesink							
			Clay Marls	Matawan					Matawan	Hazlet Sands Crosswick Clays	Clay Marls.
		Non-marine			Newer Potomac	Upper	(Island Series.)	Clark & Bibbins.‖			
							Albirupean	Lower Cretaceous	Raritan		
			Plastic Clays	Raritan			Iron Ore (?)		Patapsco	Ward's plant-bearing series held to be local exposures of this formation.	
					Older Potomac	Middle	Aquia Creek				
			Potomac					Upper Jurassic (?)	Arundel	Marsh's supposed Jurassic vertebrates are from this formation.	
						Basal	Mount Vernon Rappahannock James River		Patuxent		

Jura-Trias.

* Correlation Papers, U. S. Geol. Surv., Bull. 82. † Bull. Geol. Soc. Am. 6: 479–482. 1894. Jour. Geol. 2: 161–177. 1894.
‡ Ann. Rep. U. S. Geol. Surv. 15: 307–397. 1895. § Ann. Rep. State Geol. N. J. 1897. ‖ Science, II. 15: 84. 1902.

siderably less carbonaceous matter that much progress can be made. All of my specimens have been sketched immediately, before becoming dry, so that they are fairly satisfactory; the specimens however might almost be thrown away as far as concerns their value as types.

While usage would sanction the designation of poor specimens of doubtful botanical affinities as "sp." after referring them provisionally or otherwise to some genus, which practice is supposed to obviate any undue definiteness on the part of the describer; the writer in these notes has followed the laudable practice of Professor Ward, as quoted above, in believing that whatever is worth mentioning is worth a name.

Acknowledgment is due Dr. Arthur Hollick, of the New York Botanical Garden, and Professor W. B. Clark, of Johns Hopkins University, for material assistance. The specimens are all deposited at the New York Botanical Garden.

CONIFERAE.

GEINITZIA Endl. Syn. Conif. 280. 1847.

This is an entirely extinct genus of the Taxodieae with several species on both sides of the Atlantic: *G. cretacea* Unger (Austria), *G. formosa* Heer (America and Quedlinburg), *G. hyperborea* (Greenland), *G.* sp., from the Dakota, and *G. Jenneyi* Font. from the Lower Cretaceous of the Black Hills. It was founded by Endlicher in his Synopsis Coniferarum to include certain forms referred by Geinitz to *Sedites* and *Araucarites* and by Corda to *Cryptomeria*. Among the former was *Araucarites Reichenbachi* of Geinitz, which Heer in 1868 identified with the living genus *Sequoia*. Since that date this plant has been almost uniformly called *Sequoia Reichenbachi*, and many place Endlicher's *Geinitzia cretacea* under it as a synonym. Others retain the older forms under *Geinitzia*. Ward contends that the retention of the genus *Geinitzia* logically carries *Sequoia Reichenbachi* with it into that genus as the type, while on the other hand the recognition of *Sequoia Reichenbachi* logically abolishes the genus *Geinitzia*.

GEINITZIA FORMOSA Heer.

Geinitzia formosa Heer, Kreidefl. Quedlinburg (Neue Denkschr. Schweiz. Ges. **24**:) 6. *pl. 1. f. 9; pl. 2.* 1871. Newb. Fl. Amboy Clays, 51. *pl. 9. f. 9.* 1896. (Foliage.) Hollick, Trans. N. Y. Acad. Sci. **16**: 129. *pl. 12. f. 1, 2.* 1897. (Cones.)

Foliage has somewhat the appearance of that of *Sequoia Reichenbachi*, but the leaves are more crowded. Not collected by me.

Raritan: Woodbridge, N. J. Matawan: Cliffwood, N. J., foliage not found. Europe: Moletein, Quedlinburg.

SEQUOIA Endl. Syn. Conif. 197. 1847.

The genus is unique in that it contains but two dwindling representatives of its former numerous species, one of which is the most majestically graceful of trees. These two species have barely held their own through the vicissitudes of centuries since the glacial period in the little strip of country where the climate is locally favorable. Many fossil species have been described, ranging upward from the Upper Jurassic; about forty-four from this continent alone, some of them with a great lateral and vertical range.

Potomac 12, Kootanie 6, Trinity 1, Ft. Pierre 1, Cheyenne Sandstone 2, Raritan 7, Island Raritan 2, Dakota 6, Belly River 3, Montana 4, Vancouver 1, Laramie 4, Canadian Upper Laramie 3, Lignitic 1, Livingston 1, Ft. Union 2, Green River 4, Alaskan Eocene 3, Miocene 3, Payette 1, Kome beds of Greenland 5, Atane beds of Greenland 5, Patoot beds of Greenland 5, Tertiary of Greenland 6, of which 4 occur in Europe and 2 on the continent of North America.

Heer records two species from the Tertiary of Siberia, and Ettingshausen records species from the Tertiaries of eastern Australia, Tasmania and New Zealand.

SEQUOIA GRACILLIMA (Lesq.) Newb. *Pl. 48. f. 21, 22.*

Glyptostrobus gracillimus Lesq. Am. Jour. Sci. II. **46**: 92. 1868; Cret. Fl. 52. *pl. 1. f. 8, 11, 11f.* 1874; Cret.

& Tert. Fl. 32. *pl. 1. f. 6, 6b.* 1883. "Cone of Sequoia" (not described) Ill. Cret. & Tert. Pl. *pl. 11. f. 9.* 1878. Fl. Dak. Group, 36. 1892.

Sequoia gracillima Newb. Fl. Amboy Clays, 50. *pl. 9. f. 1–3.* 1896; Later Ext. Fl. 19. *pl. 14. f. 6; pl. 26. f. 9* (?).* 1898.

The earliest mention of what is presumably this species is in a contribution by Newberry,† in which he refers to cones occurring in the Cretaceous Clays near Keyport (probably this is the Cliffwood locality) which he referred to *Geinitzia*, and associated branches which he referred to *Ullmannia* Goepp. In his posthumous Later Extinct Floras, these cones are referred to *Sequoia gracillima;* in the Flora of the Amboy Clays, which was also issued posthumously, he makes the same reference and compares them to Heer's *Sequoia macrolepis* (Fl. Foss. Arct. 7: 16. *pl. 51. f. 13*) considering them identical.

Hollick describes two cones from Cliffwood as *Geinitzia formosa* Heer. They are much distorted and incrusted with pyrites and possibly should be referred to *Sequoia gracillima.* Cones of this species are very common, the silicified ones washing out of the clay on the beach and the lignified ones occurring in considerable abundance in place in the clays. I have in my collection the remains of 32 cones, some of them nearly perfect and but slightly compressed, and I have refrained from collecting innumerable poor specimens seen. The largest is 8.5 cm. long, cylindrical, somewhat flattened, measuring 14 mm. in its shorter diameter and 18 mm. in its longer diameter. Most of them average nearly this thickness but are somewhat shorter, being about 7 cm. long.

Matawan: Cliffwood, N. J. (foliage not found).

Raritan (?): Keyport, N. J.

Cheyenne Sandstone: Belvidere, Kansas. Dakota Group: Sioux City, Iowa. Cretaceous (Dakota?): Whetstone Creek, New Mexico.

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* Questioned by Hollick, editor of Newberry's work.

† Proc. N. Y. Lyc. Nat. Hist. 2: 10. 1873.

Kootanie, British Northwest Terr. (Table of dist., Lesq. Fl. Dak. Gr., 222.) Forks of Pine River, Northwest Terr.*

SEQUOIA REICHENBACHI (Gein.) Heer. *Pl. 48. f. 15, 16, 17, 20.*

Araucarites Reichenbachi Geinitz, Characteristik Schichten und Petrefacten Sachs-böhm. Kreidegebirges, **3**: 98. *pl. 24. f. 4.* 1842.

Cryptomeria primaeva Corda; Reuss, Verstein. Böhm. Kreidef. 89. *pl. 48. f. 1–11.* 1846.

? *Geinitzia cretacea* Endl. Syn. Conif. 281. 1847.

Araucaria Reichenbachi Debey, Entwurf. Geogn.-geogenet. Darst. Gegend Aachen 63, 64. (Nachträge) 1849.

Sequoia Reichenbachi Heer, Fl. Foss. Arct. **1**: 83. *pl. 43. f. 1d, 2b, 5a.* 1868; **3**: 77, 101, 126. *pl. 20. f. 1–8; pl. 12. f. 7c, d; pl. 28. f. 2.* 1875; **4**: 50 (Cape Staratschin, Spitzbergen); **6**^{2}: 16, 52. *pl. 28. f. 7.* 1882. Lesq. Cret. Flora, 51. *pl. 1. f. 10, 10b.* 1874; Fl. Dak. Group, 35. *pl. 2. f. 4.* 1892. Dawson, Trans. Roy. Soc. Can. 21. 1882. Fontaine, Potomac Flora, 243. *pl. 118. f. 1, 4; pl. 119. f. 1–5; pl. 120. f. 7, 8; pl. 122. f. 2; pl. 167. f. 5.* 1889. Newberry, Fl. Amboy Clays, 49. *pl. 9. f. 19.* 1896. Hollick, Trans. N. Y. Acad. Sci. **12**: 30. *pl. 1. f. 18.* 1892; **16**: 128. *pl. 12. f. 3b, 5.* 1897.

Abietites dubius Lesq. Tert. Flora, 81. *pl. 6. f. 20, 21, 21a.* 1878.

Our specimens from near Cliffwood are possibly related to the fragments which Hollick refers to *Geinitzia formosa* Heer, but I think this is rather unlikely, as his specimens are much more elongated and more like the cones of *Sequoia gracillima*. I feel certain that these cones are those of this species rather than fragments or immature cones of some other, for while the specimens preserved are rather fragmentary, resembling except in length those cones of *Sequoia*

* Lesquereux figures (Tert. Fl. *pl. 65. f. 5, 5a*) fragments of cones from the Green River group (Tertiary) at Castellos Ranch, Colorado, which are very similar if not identical with this species.

gracillima which have become lignified instead of silicified, I found one nearly perfect cone, which was about 3 cm. in length by about 2 cm. in diameter, which agreed almost exactly with Heer's figures of this species.

This was unfortunately smashed in transit, so that I now have only the recollection of it, which is not apt to be considered good evidence. However, my first thought on uncovering it was that it was a cone of *S. Reichenbachi.* The foliage of this species is rather common in the clays at this point and we would reasonably expect to find the cones; the former are very fragmentary. Poorly preserved branchlets of *Cunninghamites squamosus* can often be traced for several inches, but the *Sequoia* remains are usually not over an inch in length. The leaves are less closely set than in *C. squamosus* and longer, often 9 to 10 mm., much more slender and more spreading.

The best known localities for this species are:

True Laramie and Livingston Beds: Bozeman coal field, Montana. Montana Formation: Point of Rocks, Wyoming. Raritan: Woodridge, N. J. Matawan: Clifford, N. J. Belly River series: Belly River, Canada. Potomac Formation: Dutch Gap Canal and Fredericksburg, Va. Dakota Group: Ft. Harker, Kansas. Kootanie: Great Falls, Montana. Kome Beds: Pattorfik, Avkrusak, Angiarsut, Erkorfat, Kaersuarsuk. Atane Beds: Unter Atanekerdluk. Europe: Wernsdorf (Urgonian) Saxony (Cenomanian), Quedlinburg, Moletein (Senonian), Rainberg bei Salzburg, Brandenberg, Tyrol, southern France (Turonian), Clays at Aachen, Prussia, Quadersandstein at Hartz, Bohemia. Cretaceous: Tottenville, Staten Island. Lower Cretaceous: Black Hills.

While this species had a wide vertical and areal distribution ranging from the Upper Jurassic through the Cretaceous, it is best developed in the Lower Cretaceous.

Sequoia Reichenbachi (Gein) Heer.? *Pl. 48. f. 18.*

An oval shaped cone 3 cm. in diameter by 4 cm. long, too obscure for exact determination. It resembles some of the

cones from the Potomac formation which Fontaine refers to this genus. Is about the same size and character as the cone of *Sequoia Reichenbachi* which Ward figures from the Black Hills (Ann. Rep. U. S. Geol. Surv. **19**[2]: 674. *pl. 166. f. 1*).

ARAUCARITES Presl, in Sternb. Vers. **2**: 203. 1833.

ARAUCARITES OVATUS Hollick.

Araucarites ovatus Hollick, Trans. N. Y. Acad. Sci. **16**: 128. *pl. 12. f. 3a, 4.* 1897.

While these remains are undoubtedly related to the genus *Araucaria*, their size would seem to indicate a nearer relationship to the genus *Agathis* Salisb. (*Dammara* Lam.). The only other American post-Jurassic references to *Araucarites* are two species of cones from the Potomac which Fontaine so identifies. The genus *Araucaria* of Jussieu occurs abundantly from the Jurassic upward; Fontaine describes three species from the Potomac formation and Lesquereux a doubtful species from the Dakota Group. Wood of this type has been identified by Knowlton from the Triassic (?) and the Lower Cretaceous of South Dakota. All of the foregoing have very small, more or less imbricated and compressed leaves, while this species of Hollick's is much larger and suggests similarity with *Nageiopsis*, so largely developed in the Potomac, or various forms referred to *Podozamites*, *Dammara*, etc., the exact affinity of which is unknown.

DAMMARA Lam. Encycl. **2**: 259. 1786.

The living species are included in the genus *Agathis* Salisb. and are four in number, ranging from the Malayan Islands and Philippines to Australia and New Zealand.

DAMMARA CLIFFWOODENSIS Hollick. *Pl. 48. f. 8–11.*

Dammara (?) *Cliffwoodensis* Hollick, Trans. N. Y. Acad. Sci. **16**: 128. *pl. 11. f. 5–8.* 1897.

These problematical remains are very abundant in the clays at Cliffwood as well as in the Amboy Clays and the Cretaceous of Staten Island and Block Island (Hollick). David

White and Hollick have found them at Martha's Vineyard and they are known from the Atane and Patoot beds where Heer differentiates *Dammara borealis*,* *D. macrosperma*, and *D. microlepis* as well as very similar remains which he describes as *Eucalyptus Geinitzi*. These latter remains Newberry considers are generically the same as those referred to *Dammara* and not related to *Eucalyptus*. However this may be, undoubted leaf-remains of *Eucalyptus* have been found in these various American Cretaceous strata and it does not seem unreasonable that the fruit should also be present. It is quite true that various leaves have been referred to *Eucalyptus* upon rather doubtful evidence, but others from both their form and venation, are unquestionably related to that genus.

The Cliffwood remains are exceedingly common; often fragmentary, however, sometimes only a portion of the resin ducts being preserved; they are very fragile and crumble readily upon handling. They vary considerably in size, some being as small as *Dammara borealis* and others being larger than those figured by Hollick from this formation.

Pl. 48, f. 10 is strikingly like the forms which Heer considers *Eucalyptus*, but the balance of our collections are evidently coniferous scales, consisting internally of a rather central resin-duct enlarged above, with four or five angular resin-ducts on each side, which seem to descend to the base of the scale; externally the scales seem to be more rounded and finely lined as in *f. 10*.

Our remains are almost exactly kite-shaped and many of them seem to have straight ascending sides and are not abruptly narrowed from above the middle as in Hollick's specimens (l. c.). Neither is there any evidence of the short mucronate point on the crown; on the contrary *f. 10* is evenly rounded. At the same time it seems best to refer our remains to Hollick's species, at least until we can be more certain as to the exact affinity of all these *Dammara*-like remains.

Newberry (*l. c.*) doubts their relation to *Dammara*, point-

* This species has been recorded from the Cenomanian of Bohemia.

ing out that no *Dammara*-like foliage has been found associated with them and that in the very abundant Amboy Clay specimens the scales seem to be associated with an extremely delicate juniper-like conifer; this association has never been confirmed, however. He also finds some indications of two seeds in his specimens, the living *Dammara* scales being one-seeded. Merely negative evidence as to the occurrence of *Dammara* leaves is not very conclusive, especially in view of the fact that Lesquereux has described the remains of certain leaves from the Dakota Group (*Dammarites*), which are undoubtedly related to those of the existing *Dammara robusta* Moore, of Australia, and various other remains both in this country and abroad have been referred to *Dammarites*.

Furthermore, the remains from Cliffwood which Hollick describes (*l. c.*) as *Araucarites ovatus* are very similar to those of *Agathis Dammara* Rich. (*Dammara orientalis* Lam.; *D. alba* Rumph.) the existing *Dammara* of the Malayan Islands and Philippines.

Fontaine (Potomac Fl. 264. *pl. 133. f. 8–12*) describes wedge-shaped scales under the name *Araucarites Aquiensis* from the Potomac Formation near Brooke, Va., where they are common and always found detached and unassociated with other remains. While their resemblance to those of *Dammara* may be considered somewhat far-fetched, their similar mode of occurrence is suggestive. They are as a rule larger than *Dammara*, but vary considerably in size and shape and have a transverse furrow on their upper margin.

CUNNINGHAMITES Presl, in Sternb. Vers. 2: 203. 1833.

Pending the discovery of fruit the identification of these remains with those of the existing genus *Cunninghamia* is not beyond question. *Cunninghamia* R. Br., with a single species, is at the present day an endemic genus of the China-Japan region.

CUNNINGHAMITES SQUAMOSUS Heer. *Pl. 48. f. 14, 19.*

Cunninghamites squamosus Heer, Beitr. Kreidfl. Quedlinb. 9. *pl. 1. f. 5–7.* 1872. Hollick, Trans. N. Y. Acad. Sci. 16: 129. *pl. 11. f. 3.* 1897. (Not of Hosius and Von der Marck.)

Remains of this species are the most abundant coniferous fossils in the clays at Cliffwood. They occur as twigs about the size of those figured by Hollick or smaller and demand no extended discussion. This is the only locality in this country where they have been found, but additional collections from the Amboy Clays ought to disclose them. The two specimens figured are more robust than the majority of the remains and are ten sevenths of the average size, although several large specimens were collected. On the usual-sized specimens the leaves are about 6 mm. long, closely set, stout, incurved, very much crowded in some instances and quite different in appearance from those of *Sequoia Reichenbachi* with which it is often associated.

CUNNINGHAMITES ELEGANS (Corda) Endl.

Cunninghamia elegans Corda; Reuss, Verstein. Böhm. Kreidef. 93. *pl. 49. f. 29–31.* 1846.

Cunninghamites elegans Endl. Syn. Conif. 270. 1847. Heer, Beitrag. Kreidefl. (Neue. Denkschr. Schweiz. Gesell.) 12. *pl. 1. f. 14.* 1869. Schimper, Pal. Vég. 2: 256. Heer, Fl. Foss. Arct. 7: 17. *pl. 53. f. 1.* 1883. Newb. Fl. Amboy Clays, 48. *pl. 5. f. 1–7.* 1896. Hollick, Trans. N. Y. Acad. Sci. 16: 129. *pl. 11. f. 2.* 1897. Hollick, Bull. N. Y. Bot. Garden, 2: 402. *pl. 41. f. 11.* 1902. (Knowlton, U. S. Geol. Surv. Bull. 163: 29. *pl. 5. f. 3.* 1900, probably belongs here.)

Cunninghamites squamosus Hosius & Von der Marck, Fl. Westfal. Kreide. 54. *pl. 37. f. 137–141.* (Palaeontographica, v. 26.) 1880.

Originally described from Moletein in Moravia and Mseno in Bohemia (Cenomanian), then from the chalk of Westphalia;

Heer records it from the Patoot beds of Greenland. Newberry's specimens are from "near Keyport" and are probably not from the Raritan, however in a table on page 135 he gives as an additional locality South Amboy, which is within the Raritan formation. Hollick (*l. c.*) records unmistakable remains of this species from the Matawan, but much search has not resulted in my finding it except one specimen which is doubtfully referred to this species (too poor to figure).

MORICONIA Deb. & Ett. Urweltl. Acrobryen Aachen, 59. 1859.

MORICONIA CYCLOTOXON Deb. & Ett. *Pl. 43. f. 4; 48. f. 1–4.*

Moriconia cyclotoxon Deb. & Ett. Urweltl. Acrobryen Aachen (Denkschr. Wien. Akad. 17: 239), 59. *pl. 7. f. 23–27.* 1859. Newb. Fl. Amboy Clays, 55. *pl. 10. f. 11–21.* 1896. Heer, Fl. Foss. Arct. 3^2: 97. *pl. 26. f. 18*, under the name of *Pecopteris Kudlisetensis; 6^2*: 49. *pl. 33. f. 1–9;* 7: 11. *pl. 53. f. 10, 10b; pl. 54. f. 1c* (the latter figure probably represents a *Brachyphyllum*).

Originally described from the clays at Aachen, Heer found it in the Atane and Patoot beds of Greenland and Disco Island, and Newberry in the Amboy Clays at South Amboy, N. J., where it is common. Heer's forms have the stem naked in a majority of cases; the branchlets are about 21 mm. long and the widest is 4.5 mm. wide; one branchlet with the tip missing is still 36 mm. long but only 3 mm. wide. Newberry's Amboy Clay specimens have some of the branchlets long and slender like the Arctic forms, but the majority are shorter and stouter, being 10 to 12 mm. in length by 4 mm. in width, and the stems are more uniformly leaved. Specimens from Staten and Block Islands recently reported by Hollick are also small.

All of my specimens from Cliffwood have the main stem leaved; my only complete branchlet is 34 mm. long by 9 mm. wide, in fact all of my specimens are nearly, or quite, twice as wide as any of the Amboy Clay or Greenland forms.

The figure (*pl. 43. f. 4*) shows the appearance of the main stem of a fragmentary specimen which might readily enough be taken for the pinna of a fern.

The markings on all the specimens are very obscure and it is only after the carbonized layer has dried out and blown away that they show plainly the leaf-markings as shown in the balance of the figures. No fruit has anywhere been found associated with these twigs, so that their exact relationship remains to be determined. Judging from the foliage alone Heer is inclined to place it among the Cupressineae and near to *Libocedrus*.

Libocedrus Endl. is unknown from the American Cretaceous or later formations, although the existing incense cedar, *Libocedrus decurrens* Torr., ranges from Oregon southward to southern California and is commonly cultivated. This typically northern genus reaches Australia through the East Indian region and penetrates far into South America along the Andes, thus almost surrounding the Pacific. Heer has described three fossil species from the Arctic regions, *Libocedrus gracilis* from Spitzbergen, *Libocedrus cretacea* from the Atane schists (Kardlok, Isunguak), and *Libocedrus Sabiniana* from Greenland (Atanekerdluk B, Naujat, Kugsinek, Haseninsel, Isunguak) and Spitzbergen.

ARACEAE.

ARISAEMA Martius, Flora, **14**: 459. 1831.

There are about fifty existing species, mostly of temperate and tropical Asia; three in eastern North America. Two fossil species have been provisionally referred here as follows:

ARISAEMA CRETACEUM Lesq. *Pl. 46. f. 4.*

Arisaema cretacea Lesq. Fl. Dak. Group, 38. *pl. 46. f. 1.* 1892.

Arisaema (?) *dubia* Hollick, Trans. N. Y. Acad. Sci. **16**: 130. *pl. 12. f. 6.* 1897.

The above species was founded by Lesquereux for a

monocotyledonous, probably Araceous spathe from the Dakota Group of Kansas. In all probability Hollick's specimen is of the same species. It is doubtfully a species of *Arisaema*, however, and might equally be a cycadaceous spathe. In appearance the specimen before us is very similar to some of Lesquereux's figures of *Dammarites* (Fl. Dak. Gr. *pl. 1. f. 9–11*); the fine lining is about .5 mm. apart as in the existing *Dammara robusta* Moore of Australia, but the texture is very thin and quite the opposite of the thick coriaceous leaves of *Dammara* and *Dammarites*.

Arisaema (?) Mattewanense Hollick.

Arisaema Mattewanense Hollick, Trans. N. Y. Acad. Sci. 16: 130. *pl. 12. f. 7.* 1897.

Provisionally so referred by Dr. Hollick, as the fruit of some Araceous plant.

SALICACEAE.

Salix Linn. Sp. Pl. 1015. 1753.

The willows are all extremely rapid growers and thrive in the wettest soil; they are thus apt to occur in localities favorable for fossilization. There are about 160 existing species widely distributed throughout the northern hemisphere and arctic zone, a few in the southern hemisphere; about 80 are American. There are about 46 fossil American species distributed as follows: Raritan 5, Island Raritan 4, Dakota 11, Woodbine 1, Montana 3, Vancouver 2, Laramie 4 (?), Ft. Union 1, Green River 5, Eocene 7 (?), Eolignitic 3, Tertiary 2, Miocene 5, Pleistocene 1 (?).

Heer records three from the Island of Sachalin and seven from the Tertiary of Greenland.

Salix proteaefolia flexuosa (Newb.) Lesq. *Pl. 48. f. 12; pl. 52. f. 2.*

Salix flexuosa Newb. Ann. Lyc. N. Y. 9: 21. 1868; Ill. Cret. & Tert. Pl. *pl. 1. f. 4.* 1878; Later Ext. Fl. 56. *pl. 2. f. 4; pl. 13. f. 3, 4; pl. 14. f. 1.* 1898.

Salix proteaefolia flexuosa Lesq. Fl. Dak. Group, 50. *pl. 44, f. 4, 5.* 1892.

Dakota Group: Kansas. Cretaceous: Seacliff, Long Island (Hollick, '94) and Block Island (Hollick, '98).

The smaller leaf is similar to the smaller forms referred to the above species. It resembles a number of small lanceolate leaves of varied affinities such as Lesquereux's *Andromeda affinis*, the smaller forms of *Myrica longa* Heer from the Dakota (but has a narrower base), and *Laurus angusta* Heer as figured in Fl. Foss. Arct. **7**: *pl. 57. f. 1b;* the latter is, however, considerably smaller than Heer's figures of this same species in the same work, v. 6^2, and also much smaller than the leaf which Lesquereux refers to this species in the Flora of the Dakota Group.

Were our specimen (*pl. 48. f. 12*) somewhat more linear it might be compared to *Eucalyptus Dakotensis*, but there is no doubt that it is a *Salix*. The larger leaves (*pl. 52. f. 2*) show the characteristic venation of this species.

Salix Mattewanensis sp. nov. *Pl. 51. f. 5.*

A small ovate-lanceolate leaf with an obtuse base and slender tapering tip, greatly resembling several modern willow leaves; secondaries regular, camptodrome.

Except for its small size it is very similar to *Salix membranacea* Newb. There is considerable resemblance to *Salix* sp. (Fl. Amboy Clays, *pl. 42. f. 6–8*) only the tip is more elongated. There is also some resemblance to such leaves as *Leguminosites constrictus* Lesq. and to several of the forms referred to *Cassia*.

SALIX MEEKII Newb.

Salix Meekii Newb. Ann. Lyc. N. Y. **9**: 19. 1868; Later Ext. Fl. 58. *pl. 2. f. 3.* 1898. Hollick, Trans. N. Y. Acad. Sci. **16**: 130. *pl. 13. f. 3, 4.* 1897.

S. cuneata Newb. Ill. Cret. & Tert. *pl. 1. f. 2, 3.* 1878.

S. proteaefolia lanceolata Lesq. Fl. Dak. Group, 50. *pl. 64. f. 6–8.* 1892.

Recorded by Hollick from the Matawan formation near Cliffwood, N. J.; not found by me.

POPULITES Lesq. Am. Jour. Sci. 46: 93. 1868.

Founded by Lesquereux to include leaves from the Dakota Group which are apparently related to *Populus* but differing in their generally entire margin, cordate outline, and craspedodrome venation, the latter character apparently wanting in our species. Some of Lesquereux's species have since been transferred to the genera *Grewiopsis*, *Hamamelites*, *Menispermites*, and *Cissites*, leaving seven Dakota species and one species from the Upper Cretaceous of Vancouver Island.

The genus *Populus*, although containing the oldest known dicotyledon at Kome, besides ten Dakota species and two Potomac species according to Fontaine, is so essentially a later genus that I prefer to include our leaf in the related genus *Populites*, thus obviating too great definiteness of relation to the existing genus.

Populus contains about twenty-five species in the existing flora, all of which are confined to the northern hemisphere. Some twelve of these inhabit North America. The fossil species are numerous.

Populites tenuifolius sp. nov. *Pl. 49. f. 7.*

A leaf exceeding 10 cm. in length and nearly 12 cm. in width: margin in the upper part apparently entire or perhaps a trifle undulate; about 4 cm. of the right lateral margin is preserved and seems to be slightly crenate, but the indications are very faint and may be due to the wearing away of the material. The base is not preserved, but I judge it to have been cordate. The texture is extremely thin for so large a leaf. Secondaries four or five on each side, very thin, alternate, unbranched except the basal ones, leaving the midrib at an angle of about 45° and curving upward, branching near the margin much as in *Protophyllum Sternbergii*;* basal secondaries evidently much longer than the others, giving off numerous branches to the latero-basal portion of the leaf. Areolation ill-defined, angular.

I have been at a loss to correctly determine this leaf; it bears considerable resemblance to some of Lesquereux's species of *Protophyllum*, but inasmuch as the latter is a syn-

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* Lesq. Fl. Dak. Group, *pl. 42. f. 1.*

thetic type of uncertain botanical affinities, with mostly coriaceous leaves, it has not been considered available. The only Raritan leaf with which our specimen may be compared is *Tiliaephyllum dubium*,* which it resembles in its cordate outline, delicate venation, and thin texture; like the Raritan leaf ours is represented by but a single specimen rather poorly preserved. It differs in being larger and in lacking the dentate margin, and was apparently equilateral with a straight midrib. In view of the uncertainty of Newberry's determination it is desirable that we should endeavor to get an idea of the true botanical affinity of our leaf, which it seems to me will place it among those leaves ancestral to the modern aspens or poplars. It resembles several species of *Populus*, although the latter are as a rule coriaceous or subcoriaceous, for instance *Populus Harkeriana* Lesq. from Staten Island † and the Dakota Group.‡ It may be compared with *Populus balsamoides* (?) var. *latifolia* Lesq.,§ although the latter is a Tertiary species; the margin is apparently similar and the venation is strikingly similar except at the margin.

It may also be compared with the Dakota species *Populites Lancastriensis* Lesq.‖ which it greatly resembles in size and outline; the secondaries are stouter and straighter in the latter and the basal one is less branched.

FAGACEAE.

QUERCUS Linn. Sp. Pl. 994. 1753.

About two hundred existing species of the northern hemisphere,¶ more than fifty of which occur in North America. The extinct American species number about 127, distributed

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* Newb. Fl. Amboy Clays, 109. *pl. 15. f. 15.*

† Hollick, Ann. N. Y. Acad. Sci. 11 : 419. *pl. 36. f. 8.*

‡ Lesq. Fl. Dak. Group, 44. *pl. 46. f. 4.*

§ Lesq. Cret. & Tert. Fl. 158. *pl. 31. f. 4.*

‖ Lesq. Cret. Fl. 58. *pl. 3. f. 1.*

¶ Recorded by Ettingshausen from Tertiary of New Zealand. (Trans. N. Z. Inst. v. 23.)

as follows: Raritan 2, Dakota 20, Montana 2, Vancouver 6, Laramie 17, Livingston 3, Denver 9, Ft. Union 7, Tertiary of Yellowstone Park 7, Green River 7, Eolignitic 6, Eocene 12, Miocene 25, Payette 4, Pleistocene 6, Glacial 1, Atane 7, Patoot 7, Tertiary of Greenland 15.

Quercus Hollickii sp. nov. *Pl. 51. f. 1, 2.*

Leaves subcoriaceous, obovate, obtuse, gradually narrowing to the base; secondaries strong, equidistant and parallel, alternate, camptodrome, angle of divergence about 50°; basal one third of the margin entire, above rather irregularly dentate.

These specimens evidently represent a leaf about 9 cm. in length by about 4.5 cm. in greatest width.

I have been unable to refer this to any of the described species of *Quercus* although it resembles several; in outline it is similar to *Q. Wardiana* Lesq.* from the Dakota group, but the latter is 50 per cent. larger and with different venation. There is also a resemblance to Newberry's *Q. elliptica* † but the secondaries are straighter, more ascending and more regularly arched in our specimen. Again, it may be compared to the Tertiary *Q. Olafseni* Heer, but the latter has the leaves more oval, margin more dentate, secondaries craspedodrome and straighter, greatly resembling Lesquereux's *pl. 48. f. 4* from the Fort Union Beds; in the latter, however, some of the upper secondaries run directly to the dentate points of the margin. There is, further, a resemblance to *Q. Nevadensis* Lesq., from the Pacific Coast Miocene, which however has the secondaries straighter and subcraspedodrome.

Considerable similarity is to be noted with various leaves referred to *Celastrophyllum*, as for instance *C. grandifolium* Newb., which is common in the Raritan (localities not given); our leaf is considerably shorter and relatively wider, more obovate in outline, with a more tapering base, straighter midrib and more regular secondaries.

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* Fl. Dak. Group. *pl. 7. f. 1.* 1892.
† Later Ext. Fl. *pl. 20. f. 3.* 1898.

QUERCUS HOLMESII Lesq. *Pl. 48. f. 13.*

Dryophyllum (*Quercus*) *salicifolium* Lesq. Ann. Rep. U S. Geol. & Geog. Surv. Terr. **1874**: 340. *pl. 8. f. 2.* 1876. Name preoccupied by *Quercus salicifolia* Newb.

Dryophyllum (*Quercus*) *Holmesii* Lesq. Cret. & Tert. Flora, 38. *pl. 4. f. 8.* 1883.

Quercus Holmesii Lesq. Fl. Dak. Group, 58. 1892.

Upper Cretaceous: Port McNeill, Vancouver Island. Dakota Group ?: San Juan River, S. W. Colorado.

There are a number of small-leaved oaks which resemble this species, including *Quercus Montanensis* Knowlton (Fl. Montana Form. *pl. 11. f. 10*), *Dryophyllum subfalcatum* Lesq. (*D. Bruneri* Ward) of the Laramie and the smaller forms with nearly simple margins of Newberry's Tertiary *Quercus consimilis*.

QUERCUS MORRISONIANA Lesq.

Quercus Morrisoniana Lesq. Cret. & Tert. Fl. 40. *pl. 17. f. 1, 2.* 1883. Hollick, Trans. N. Y. Acad. Sci. **16**: 131. *pl. 13. f. 11, 12.* 1897.

Recorded by Hollick from the Matawan formation near Cliffwood, N. J.; not found by me.

QUERCUS (?) NOVAE-CAESAREAE Hollick. *Pl. 51. f. 4.*

Quercus (?) *Novae-Caesareae* Hollick, Trans. N. Y. Acad. Sci. **16**: 131. *pl. 13. f. 9, 10.* 1897.

Hollick points out the resemblance of these leaves to those of *Quercus Myrtillus* Heer from Greenland and also to those of *Diospyros provecta* Velen. from Bohemia.

I have found several fragments at Cliffwood which belong here.

QUERCUS sp.

Quercus (?) *sp.*, Hollick, Trans. N. Y. Acad. Sci. **16**: 131. *pl. 14. f. 9.* 1897.

Of doubtful affinity. Hollick compares this fragment with *Quercus poranioides* Lesq. and with *Q. Thulensis* Heer, and

also suggests that it might be a fragment of *Ilex Masoni* Lesq. There are several similar fragments in my collection.

MORACEAE.

Ficus Linn. Sp. Pl. 1059. 1753.

The existing species number some six hundred shrubs and trees of the warmer parts of the globe everywhere, chiefly in Asia, Africa and the East Indian Islands. Two species enter the limits of the United States, occurring in Florida and the West Indies. About one hundred species of *Ficus* occur in America in the following formations: Potomac 2, Raritan 3, Island Raritan 5, Dakota 23, Woodbine 1, Montana 16, Vancouver 6, Laramie 21, Livingston 1, Denver 9, Ft. Union 5, Green River 5, Tertiary of Yellowstone Park 4, Eocene 6, Eolignitic 6, Miocene 7, Atane 3, Patoot 2, Greenland Tertiary 1.

Recorded by Ettingshausen from Tertiary of New Zealand (Trans. N. Z. Inst. v. 23); now extinct there, though living in Australia.

Ficus reticulata (Lesq.) Knowlton. *Pl. 52. f. 5; pl. 53. f. 1, 4.*

Laurophyllum reticulatum Lesq. Ann. Rep. U. S. Geol. & Geog. Surv. Terr. 1872: 425. 1873; Cret. Flora, 76. *pl. 15. f. 4, 5.* 1874.

Ficus laurophylla Lesq. Ann. Rep. U. S. Geol. & Geog. Surv. Terr. 1874: 342. *pl. 5. f. 7.* 1876. Cret. & Tert. Fl. 49. *pl. 1. f. 12, 13.* 1878; Fl. Dak. Group, 85. 1892.

Ficus reticulata Knowlton, Bull. U. S. Geol. Surv. 152: 104. 1898.

Heretofore known from the Dakota Group of Kansas. The Cliffwood remains consist of the impressions of the under surface of leaves rather fragmentary, and indicate an oblong-lanceolate leaf 2–3.5 cm. in width, with an entire margin and rather stout midrib; secondaries branch at an obtuse angle, unequal, becoming marginal; venation some-

what irregular. There is some resemblance to the Greenland leaves which Heer (Fl. Foss. Arct. **7**: *pl. 79. f. 4*) refers to *Diospyros brachysepala* A. Br.

FICUS WOOLSONI Newb. *Pl. 47. f. 7.*

Ficus Woolsoni Newb.; Hollick, Trans. N. Y. Acad. Sci. **12**: 6. *pl. 2. f. 1, 2c.* 1892; Newb. Fl. Amboy Clays, 70. *pl. 20. f. 3; pl. 23. f. 1–6.* 1896.

This species is thus far only represented by a small fragment from Cliffwood, although common in the Raritan Clays at Sayreville and Woodbridge, and also reported from Kreischerville, Staten Island, by Hollick.

PROTEACEAE.

PROTEOIDES Heer, Phyll. Crét. Nebr. 17. 1866.

This extinct genus, which is supposed to be allied to the existing genus *Protea*, has some eight fossil American species as follows: Raritan 2, Dakota 4, Mill Creek 1, Vancouver 3. Many fossil species of Proteaceae have been described from the European Tertiary but considerable doubt has been expressed as to the real affinity of many of them, their resemblance to various species of Coniferae, Meliaceae, Sapindaceae and Myricaceae being pointed out.

PROTEOIDES DAPHNOGENOIDES Heer. *Pl. 51. f. 6–9.*

Proteoides daphnogenoides Heer, Phyll. Crét. Nebr. 17. *pl. 4. f. 9, 10.* 1866. Newb. Fl. Amboy Clays, 72. *pl. 17. f. 8, 9; pl. 32. f. 11, 13, 14; pl. 33. f. 3; pl. 41. f. 15.* 1896. Lesq. Cret. Fl. 85. *pl. 15. f. 1, 2.* 1874. Hollick, Trans. N. Y. Acad. Sci. **11**: 98. *pl. 3. f. 1, 2.* 1892; **12**: 36. *pl. 2. f. 4, 9, 13.* 1893; Bull. Torrey Club, **21**: 52. *pl. 177. f. 1.* 1894; Ann. N. Y. Acad. Sci. **11**: 420. *pl. 36. f. 1–3.* 1898.

Remains of this species are common in the clays near Cliffwood, but very fragmentary. Previously recorded from the Dakota group at Decatur, Nebraska; Raritan at Woodbridge, Sayreville, etc., N. J.; the Mill Creek series at Mill Creek and the Cretaceous on Staten Island and Long Island.

BANKSIA Linn. f. Suppl. 15. 1781.

The existing species number about fifty and are confined to the Australian region. Two fossil species have been identified from American strata, but whether or not they are allied to the living *Banksiae* is not altogether certain.

BANKSIA PUSILLA Velen.

Banksia pusilla Velen. Fl. Boehm. Kreidef. 7 (32). *pl. 1* (*9*). *f. 14–17*. 1883. Hollick, Trans. N. Y. Acad. Sci. 16: 132. *pl. 13*. *f. 7*. 1897.

With the exception of *Banksia Helvetica* Heer, which Lesquereux records from the Eolignitic of Mississippi, this genus is not found elsewhere on this continent, although species referred to this and the allied genus *Banksites* occur in the European Tertiary. It is essentially a later genus, with upwards of fifty existing species which are all confined to the Australian region. The above species is very similar to *Santalum Americanum* Lesq. (Cret. & Tert. Fl. *pl. 32*. *f. 7*) of the western Tertiary.

NYMPHAEACEAE.

NELUMBO Adans. Fam. Pl. 2: 76. 1763.

But two living species are known, *N. Nelumbo* (L.) Karst. of eastern Asia and *N. lutea* (Willd.) Pers. of eastern North America, giving emphasis to the well-known similarity of these two floras. The genus appeared in the middle Cretaceous and ranges to the Miocene Tertiary, increasing regularly in size. There are one Asiatic, seven European and nine American fossil species,* all of the American species, unless it be Heer's from Atane, being from a considerably higher horizon than our Cliffwood specimen.

Exceptions to the latter statement are unpublished species from Long Island and Martha's Vineyard, discovered by Dr. Hollick.

Nelumbo primaeva sp. nov. *Pl. 43*. *f. 1*.

This is undoubtedly a portion of a leaf of *Nelumbo* — too

* The living and fossil species are enumerated by Hollick in Bull. Torrey Club, 21: 307. 1894.

small a fragment, however, for rigid determination. It represents a small-leaved species with leaves apparently about the same size as those of *Nelumbo Laramiensis* Hollick (*l. c. f.* in text); the cross venation is obliterated, however, and the primary veins are only eight in number instead of twelve, as is the case in *N. Laramiensis.** *Nelumbo intermedia*,† of the Montana formation, is of about the same size, but has twelve or thirteen weak primary veins. *Nelumbo Dawsoni* Hollick,‡ from the Canadian Belly River, is also a small leaf, but has eighteen primary veins. Dawson has described,§ but not figured, a small leaf from the Canadian Laramie, under the name of *Nelumbium Saskachuensis*, of similar size and with only seven primaries.

MAGNOLIACEAE.

MAGNOLIA Linn. Sp. Pl. 535. 1753.

There are about fifteen existing species of *Magnolia*, confined to eastern North America, eastern Asia and the Himalayan region. The fossil species are numerous, there being over forty from continental America besides those from Greenland. The distribution of the American fossil species is as follows: Raritan 7, Island Raritan 8, Dakota 11, Atane 4, Mill Creek 1, Woodbine 2, Montana 2, Vancouver 2, Laramie 7, Denver 1, Ft. Union 2, Eocene 6, Eolignitic 5, Miocene 5, Greenland Tertiary 6.

MAGNOLIA OBTUSATA Heer. *Pl. 47. f. 4.*

Magnolia obtusata Heer, Fl. Foss. Arct. 6[2]: 90. *pl. 15. f. 12; pl. 21. f. 3.* 1882. Lesq. Fl. Dak. Group, 201. *pl. 60. f. 5, 6.* 1892.

This leaf resembles greatly the smaller of the two figures which are figured respectively by each of the above authors.

* Dr. Hollick, who has seen a figure of this leaf, writes: "Very close if not identical with *Nelumbo Laramiensis*."

† Knowlton, Fl. Montana Form. (Bull. U. S. Geol. Surv. 163:) 53. *pl. 19. f. 3–5.* 1900.

‡ *Brasenia antiqua*, Daws. Trans. Roy. Soc. Can. 3: sec. 4, 15, *f.* 1886.

§ Daws. *ibid.*, 5: sec. 4, 35. 1888.

Previously recorded from the Atane schists of Greenland and the Dakota group of Kansas.

MAGNOLIA WOODBRIDGENSIS Hollick. *Pl. 53. f. 5; pl. 57. f. 2.*

Magnolia Woodbridgensis Hollick, in Newb. Fl. Amboy Clays, 74. *pl. 36. f. 11; pl. 57. f. 5–7.* 1896. Hollick, Trans. N. Y. Acad. Sci. **16**: 133. *pl. 14. f. 8.* 1897; Ann. N. Y. Acad. Sci. **11**: 60. *pl. 3. f. 2.* 1898.

While the fragments shown on *plate 53* have the venation entirely obscured, I have no hesitation in referring them to the above species, especially as I have found other smaller fragments with the characteristic venation of *Magnolia*.

Judging from the nearly parallel lateral margins of the fragment shown on *plate 57* it would seem to indicate a rather longer leaf than the typical *Magnolia Woodridgensis*, a leaf more like *Magnolia Boulayana* Lesq. or *Magnolia glaucoides* Newb. The incomplete nature of the specimen, however, and the total obliteration of the venation make it preferable to place it under *M. Woodbridgensis*. Leaf-blade apparently quite thick.

MAGNOLIA TENUIFOLIA Lesq. *Pl. 47. f. 10.*

Magnolia tenuifolia Lesq. Am. Jour. Sci. **46**: 100. 1868; Cret. Flora, 92. *pl. 21. f. 1.* 1874; Fl. Dak. Group, 198. *pl. 24. f. 1.* 1892.

Previously known from the Dakota Group at Decatur, Neb., Kansas, and Peace River, Northwest Territory.

Our fragment is very similar to *f. 1. pl. 24*, Fl. Dak. Group, of this species, except that the secondaries are somewhat straighter and more regular.

There is considerable resemblance to *Magnolia Capellinii* Heer, which is doubtfully recorded from Sayreville, N. J., Glen Cove, L. I., and Martha's Vineyard, as well as from the Dakota of the West and from Greenland.

Ours, while only a fragment, denotes a more elongated leaf than that of *M. Capellinii*.

LAURACEAE.

LAURUS Linn. Sp. Pl. 369. 1753.

As commonly restricted, the existing species are but two, of southern Europe, the Canary Islands and Madeira. The family is large and chiefly tropical. The fossil species are numerous, over thirty being found on this continent. It may be remarked, however, that there is considerable uncertainty in the generic diagnoses which are based upon nothing but leaf remains of the Laurineae. Remains referred to *Laurus* are common in the European Tertiary and Heer records one species from the Tertiary of Siberia, besides four at Atane, three at Patoot, and four in the Tertiary of Greenland. The American species are distributed as follows: Raritan 3, Island Raritan 4, Dakota 11, Mill Creek 1, Woodbine 1, Montana 3, Vancouver 1, Cret. of N. W. Terr. 1, Laramie 4, Livingston 1, Denver 3, Ft. Union 2, Tertiary of Yellowstone Park 2, Eocene 1, Eolignitic 4, Miocene 7.

LAURUS HOLLAE Heer. *Pl. 50. f. 7, 8; pl. 52. f. 7, 8.*

Laurus Hollae Heer, Fl. Foss. Arct. 6[2]: 76. *pl. 33. f. 13; 44. f. 5b; 45. f. 3.* 1882. Lesq. Fl. Dak. Group, 92. *pl. 12. f. 8.* 1892. Hollick, Trans. N. Y. Acad. Sci. **12**: 7. *pl. 2. f. 17.* 1892.

Previously known from the Dakota Group, Kansas; Cretaceous, Staten Island; Atane schists, Greenland. Ours are rather poor specimens for positive determination; as far as they go they agree admirably with the above species.

LAURUS PROTEAEFOLIA Lesq. *Pl. 47. f. 9; pl. 49. f. 6.*

Laurus proteaefolia Lesq. Bull. U. S. Geol. and Geog. Surv. Terr. **1**: 393. 1876; Ann. Rep. *ibid.* **1874**: 342. *pl. 5. f. 1, 2.* 1876; Cret. & Tert. Fl. 52. *pl. 3. f. 9, 10; pl. 16. f. 6.* 1883; Fl. Dak. Group, 92. 1892.

Lesquereux's specimens were from the Dakota Group at Morrison, Col., and Fort Harker, Kansas. The Cliffwood forms which Hollick refers to *Laurus plutonia* Heer are somewhat larger than the majority of Heer's figures of that species, and our remains which seem to be species of *Laurus*

are larger still and more ovate in form, with less ascending secondaries. They are intermediate in size among Lesquereux's figures of *L. proteaefolia*.

LAURUS PLUTONIA Heer. *Pl. 50. f. 9–11.*

Laurus plutonia Heer, Fl. Foss. Arct. 6^2: 75. *pl. 19. f. 1d, 2–4; pl. 20. f. 3a, 4–6; pl. 24. f. 6b; pl. 28. f. 10, 11; pl. 42. f. 4b;* 7: 30. *pl. 58. f. 2; pl. 62. f. 1a.* Lesq. Fl. Dak. Group, 91. *pl. 13. f. 5, 6; pl. 22. f. 5.* 1892. Newb. Fl. Amboy Clays, 85. *pl. 16. f. 10, 11.* 1896. Hollick, Trans. N. Y. Acad. Sci. **12**: 236. *pl. 6. f. 1.* 1893; Bull. Geol. Soc. Am. **7**: 13. 1895; Trans. N. Y. Acad. Sci. **16**: 132. *pl. 13. f. 5, 6.* 1897; Ann. N. Y. Acad. Sci. **11**: 60. *pl. 4. f. 6, 7.* 1898.

Recorded from the Raritan, locality not given; Matawan, Cliffwood, N. J.; Dakota group, Kansas and Minn. (?); Cretaceous, Glen Cove, L. I., Martha's Vineyard and Block Island; Middle Cretaceous at Atane and Patoot, Greenland.

This is another species which was very common throughout eastern North America from Greenland to New Jersey during the Middle Cretaceous. The leaves were rather variable in outline, Newberry's Amboy Clay forms and those from Cliffwood which Hollick refers to this species being considerably broader than the majority of Heer's specimens. The leaves from the Dakota which Lesquereux identifies with this species are, on the other hand, smaller and agree fairly well with the leaves in our collections which seem to belong to this species. The latter agree closely with Heer's figures and differ considerably from Hollick's forms from this formation. About the same size as the Block Island leaf which Hollick refers to this species.

Laurus Hollickii sp. nov. *Pl. 52. f. 4.*

A small lanceolate Lauraceous leaf about 8 cm. long and 1.5 cm. in greatest width, which is at a point about half way between the apex and base, the blade tapering about equally in both directions; secondaries four or five on each side,

leaving the midrib at an angle somewhat less than 45° and curving upward with a long sweep, becoming nearly parallel with the margin, along which they form small shallow arches, the connecting branches to the secondary next above being small and transverse.

Species dedicated to Dr. Arthur Hollick, who suggested its Lauraceous affinity.

This species is quite similar to *Daphnophyllum Dakotense* Lesq. from the Dakota group, which Lesquereux compares with *Daphne protogaea* Ett.* Our leaf is somewhat narrower and the distal portions of the secondaries are straighter. There is also considerable resemblance in outline to various species of *Salix* and some of the lanceolate species of *Ficus*.

LAUROPHYLLUM Göpp. Tertiarfl. Java, 45. 1854.

An entirely extinct genus containing leaves supposed to be allied to *Laurus* and including five American species in the Raritan, Mill Creek and Upper Cretaceous.

LAUROPHYLLUM ANGUSTIFOLIUM Newb. *Pl. 47. f. 1, 5, 8, pl. 49. f. 1–5.*

Laurophyllum angustifolium Newb. Fl. Amboy Clays, 86. *pl. 17. f. 10, 11.* 1896.

Remains of leaves, which by their narrow elongated shape, thick midrib, and coriaceous texture are allied to this species of Newberry from the Amboy Clays at Woodbridge are very common at Cliffwood. The remains are very poor, however, consisting of larger or smaller fragments of the basal portions of leaves. The petiole (preserved in *f. 5*) is short and stout.

Newberry compares his leaves with some of Heer's *Myrica longa*, but the latter lack the straight narrowly ascending basal margins and are rather abruptly rounded. If Arctic analogues are necessary we may point out the resemblance to the Tertiary *Laurus Reussii* Ett. or to forms of *Laurus angusta* Heer from Atane (Fl. Foss. Arct. 6^2: *pl. 43, f. 1c*).

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* Fl. Bilin. pt. 2, 13. *pl. 34. f. 1–3.* 1868.

SASSAFRAS Nees & Eberm. Handb. Med. Pharm. Bot. **2**: 418. 1831.

At the present day a monotypic genus of eastern North America, although inhabiting Europe before the Glacial period in both the Tertiary and Cretaceous ages. Numerous fossil leaves have been referred to this genus ranging from the Potomac formation upward. While some of these are undoubtedly ancestral *Sassafras* species, others are just as undoubtedly not related to *Sassafras;* for instance we would refer *Sassafras Harkerianum*, *S. obtusum* and *S. cretaceum obtusum* to *Cissites;* we would refer *S. dissectum*, *S. dissectum symmetricum*, *S. mirabile*, *S. papillosum*, *S. recurvatum*, *S. dentatum* and *S. grossedentatum* to *Platanus* or possibly to *Protoplatanus*. The two dozen or more ancient American species occur in the following formations: Potomac 3, Cheyenne Sandstone 3, Raritan 4, Island Raritan 2, Matawan 1, Dakota 14, Vancouver 1, Canadian Upper Laramie 2.

Heer describes two species from Atane, one of which is identical with a Dakota form; one species from Patoot; and one from the Tertiary of Greenland. Velenovsky identifies *S. acutilobum* in the Cenomanian of Bohemia, and several species have been described from the European Tertiary formations.

SASSAFRAS ACUTILOBUM Lesq. *Pl. 45. f. 1, 2.*

Sassafras acutilobum Lesq. Cret. Flora, 79. *pl. 14. f. 1, 2.* 1874; Cret. & Tert. Fl. 56. *pl. 5. f. 1, 5.* 1883; Fl. Dak. Group, 100. 1892. Newb. Fl. Amboy Clays, 87. *pl. 25. f. 1–10; pl. 26. f. 2–6.* 1896; Later Ext. Fl. 98. *pl. 7. f. 1.* 1898 > *S. cretaceum.* Hollick, Trans. N. Y. Acad. Sci. **12**: 236. *pl. 7. f. 1.* 1893. **16** : 132. *pl. 14. f. 13.* 1897. Velen. Fl. Böhm. Kreidef. 4: 2. *pl. 2. f. 1.* 1886.

S. recurvatum Heer, Fl. Foss. Arct. 6^2: 74. *pl. 39. f. 4.* 1882; not Lesq.

There can be no doubt that this rather fragmentary leaf is referable to *Sassafras acutilobum* as commonly understood.

In outline it is almost identical with Lesquereux's typical leaf from the Dakota Group, the only differences being its slightly smaller size and somewhat wider median lobe. It is also very similar to the leaf from the Bohemian Cretaceous which Velenovsky refers to this species, the only difference being the less conical lobes. With Newberry's Amboy Clay forms there is a general resemblance to the more typical specimens. Hollick, ('97) found a small fragment in this (Clay Marl) formation which he thought might be referable to this species. With the question of the proper generic relations of this species we are not here concerned. In another place * I have expressed doubt as to the validity of its reference to *Sassafras*.

ACERACEAE.

ACER Linn. Sp. Pl. 1054. 1753.

There are about one hundred existing species of maples. The fossil species are also quite numerous, there being some twenty-six fossil American forms distributed as follows: Raritan 1, Island Raritan 1, Belly River 1, Laramie 5, Denver 1, Ft. Union 3, Green River 3, Eocene 3, Miocene 8, Pleistocene 3.

Heer records one from the Tertiary of Siberia, one from the Tertiary of Manchuria, three from the Island of Sachalin, two from Patoot, and five from the Tertiary of Greenland. Ettingshausen records maples in the Tertiary of Australia, Tasmania and New Zealand.

ACER PAUCIDENTATUM Hollick.

Acer paucidentatum Hollick, Trans. N. Y. Acad. Sci. **16**: 132. *pl. 14. f. 2, 3.* 1897.

As remarked by Hollick this maple resembles several Tertiary species. *Acer* is only represented by fruit in the New Jersey Raritan, although a small leaf has been found in that formation on Staten Island.

SAPINDUS Linn. Sp. Pl. 367. 1753.

Sapindus is at the present day a chiefly tropical genus of about ten species of Asia and America. The only existing

* Bot. Gaz. 34: 438. 1902.

North American species are *S. marginatus* Willd., which ranges from Kansas to northern Mexico and eastward to Georgia and Florida; *S. Saponaria* Linn., of the Florida Keys, West Indies and Venezuela; and *S. Drummondii* H. & A. The American fossil species are numerous, there being twenty-one or more forms distributed as follows: Island 1, Matawan 1, Dakota 2, Denver 1, Upper Laramie 1, Eocene, Ky. 1, Brandon, Vt. 1, Green River 7, Fort Union 5, Tertiary of Yellowstone Park 2, Eolignitic 4, Miocene 1, Greenland 3.

Did we assume that these fossil leaflets should be of uniform size and form, as they are in our existing species of the Southwest, the number of fossil species would be greatly multiplied.

SAPINDUS MORRISONI Lesq. *Pl. 47. f. 2, 3.*

Sapindus Morrisoni Lesq. Cret. & Tert. Fl. 83. *pl. 16. f. 1, 2.* 1883; Fl. Dak. Group, 158. *pl. 35. f. 1, 2.* 1892. Heer, Fl. Foss. Arct. 6²: 96. *pl. 40. f. 1; pl. 41. f. 3; pl. 43. f. 1a, b; pl. 44. f. 7, 8.* 1882. Hollick, Trans. N. Y. Acad. Sci. **11**: *pl. 3. f. 5.* 1892; **12**: 235. *pl. 6. f. 3.* 1893; Bull. Torrey Club, **21**: 57. *pl. 179. f. 8.* 1894; Bull. Geol. Soc. Am. **7**: 13. 1895; Ann. N. Y. Acad. Sci. **11**: 422. *pl. 36. f. 4.* 1898. White, Am. Jour. Sci. III. **39**: 99. *pl. 2. f. 12.* 1890.

The Cliffwood forms are small leaves with a considerably inequilateral base and numerous somewhat ascending irregularly curved camptodrome secondaries. There is no question but what this is a species of *Sapindus*; it agrees quite well with Lesquereux's Cret. & Tert. Fl. *f. 2*, and Fl. Dak. Group, *f. 2*, and Hollick's specimen from Tottenville, Staten Island, all of which are rather smaller than the other figured leaves of this species. Hollick * identifies two fairly perfect leaves from this horizon with Velenovsky's *Sapindus apiculatus* from the Bohemian Cretaceous. These leaves are somewhat smaller than our specimens and less full at the

* Trans. N. Y. Acad. Sci. **16**: 133. *pl. 13. f. 1, 2.* 1897.

base on the larger side, otherwise they are quite similar. They may be either small leaves of *Sapindus Morrisoni* or else new forms altogether. It may well be that the leaves referred to the widely distributed *Sapindus Morrisoni*, as indicated above, embrace more than one species.

This is another species which we could expect to find in the Raritan formation.

SAPINDUS APICULATUS Velen.

Sapindus apiculatus Velen. Fl. Böhm. Kreidef. **3**: 6 (53). *pl.* 7 (*22*). *f.* *1–8*. 1884. Hollick, Trans. N. Y. Acad. Sci. **16**: 133. *pl.* *13*. *f.* *1*, *2*. 1897.

As remarked under *Sapindus Morrisoni*, this might well be a small leaf of that species. Recorded by Hollick from the Matawan; not found by me.

CELASTROPHYLLUM Göpp. Tertiärfl. Java, 52. 1854.

This extinct genus includes leaves related to those of *Colastrus*. It has ten species in the Potomac, ten in the Raritan, one in the Island series, seven in the Dakota, two in the Matawan, one in the Atane beds and three in the Patoot beds.

Celastrophyllum elegans sp. nov. *Pl.* *43*. *f.* *6*.

A handsome ovate-lanceolate leaf about 6 cm. long and 10 mm. wide at its widest part which is about midway between the base and the apex; with a somewhat wedge-shaped base, an evenly rounded apex and a slightly undulating margin; there are eleven shallow indentations on each side, the lowest about 6 mm. from the base; petiole rather stout, 10 mm. in length; secondaries branch at an angle of somewhat more than 45° and are straight to within a short distance of the margin, curving and forming arches only about one millimeter from it.

Hollick refers a leaf from this formation to *Celastrophyllum Newberryanum;* ours is a narrower longer leaf with more regular secondaries. Compared with the Amboy Clay leaves of *C. Newberryanum* ours is a longer more slender leaf. *C. Newberryanum* was however an abundant and very variable leaf and some of Newberry's figures approach ours quite

closely, for instance, Fl. Amboy Clays, *pl. 49. f. 10.* Our leaf is also somewhat similar to some of the Amboy clay leaves which Newberry refers to *C. crenatum* Heer, though the latter is stouter and averages much larger.

C. grandifolium Newb. is of somewhat the same proportions but about three times as large. The Dakota species except *C. decurrens* are much smaller leaves. The Potomac species are mostly smaller broader leaves of rather obscure affinities.

CELASTROPHYLLUM NEWBERRYANUM Hollick.

Celastrophyllum Newberryanum Hollick; Newb. Fl. Amboy Clays, 101. *pl. 49. f. 1–27.* 1896; Trans. N. Y. Acad. Sci. **16**: 133. *pl. 14. f. 1.* 1897.

This small-leaved *Celastrophyllum* is abundant in the upper Raritan beds at South Amboy and we would naturally expect it to extend upward into the Cliffwood beds, where it is recorded by Hollick.

RHAMNACEAE.

RHAMNUS Linn. Sp. Pl. 193. 1753.

About seventy-five existing species, mostly north temperate, a few tropical and a few south temperate; eleven inhabit North America. Thirty-three species are found fossil on this continent in the following formations: Island Raritan 2, Dakota 6, Montana 1, Laramie 10, Denver 6, Ft. Union 2, Green River 3, Eolignitic 2, Tertiary 1.

Heer records one from the Tertiary of Manchuria, one from the island of Sachalin, two from Atane, one from Patoot, and eight from the Tertiary of Greenland.

Rhamnus Novae-Caesareae sp. nov. *Pl. 50. f. 5, 6.*

These leaves are somewhat similar in outline and venation to what Hollick calls *Quercus* (?) *Novae-Caesareae* from this same locality, only our specimens are less perfect and considerably larger. Their true affinity seems to be with *Rhamnus*, and I have been unable to associate them with any of the

described species. Remains are fragmentary, but indicate a simple ovate-lanceolate leaf 7–10 cm. long by about 2.25 cm. wide, with ascending camptodrome secondaries and transverse tertiaries.

RHAMNUS INAEQUILATERALIS Lesq.

Rhamnus inaequilateralis Lesq. Fl. Dak. Group, 170. *pl. 37. f. 4–7.* 1892. Hollick, Trans. N. Y. Acad. Sci. **16**: 133. *pl. 13, f. 8.* 1897.

The Cliffwood forms are identical with the smaller of Lesquereux's leaves. Recorded by Hollick from the Matawan formation; not found by me.

PALIURUS Mill. Gard. Dict., ed. 7. 1759.

There are only two existing species, one confined to southern China and Japan, and the other to southern Europe and western Asia. The fossil species are numerous, some sixteen occurring on this continent; it is pertinent to remark, however, that in the absence of fruit *Paliurus* is practically indistinguishable from *Zizyphus* or *Ceanothus*.

Raritan 1, Island Raritan 3, Dakota 5, Mill Creek 2, Vancouver 1, Laramie 4, Canadian Upper Laramie 1, Denver 3, Ft. Union 2, Green River 2, Miocene 1.

Heer records one from the Tertiary of Siberia, one from the Island of Sachalin, one from Patoot, and three from the Tertiary of Greenland.

PALIURUS INTEGRIFOLIUS Hollick (?).

Paliurus integrifolius Hollick, Bull. Torrey Club, **21**: 57. *pl. 177. f. 5, 8, 12.* 1894; Trans. N. Y. Acad. Sci. **16**: 133. *pl. 14. f. 10.* 1897.

This reference of a fragment from near Cliffwood was only provisional. The specimen represents the basal fragment of a leaf which is rather large for *Paliurus* and lacks the lateral branches of the primaries which ought to be present in the left hand portion of the specimen. It might well represent the basal portion of some of the leaves from the Raritan formation which Newberry referred to *Cissites formosus* Heer. Not found by me.

MYRTACEAE.

EUCALYPTUS L'Her. Sert. Angl. 18. 1788.

There are about one hundred and forty existing species of great variety of form, foliage and blossom, confined to the Australian region, none occurring in New Zealand on the one hand or Asia on the other.* Nine fossil species have been referred to this genus from American strata, most of which are doubtfully determined owing to the uncertainty of leaf remains: Island Raritan 2, Dakota 3, Raritan 4, Laramie 1, Green River 1, Atane 2.

EUCALYPTUS GEINITZI Heer. *Pl. 53. f. 3.*

Myrtophyllum (*Eucalyptus?*) *Geinitzi* Heer, Fl. Foss. Arct. 3[2]: 116. *pl. 32. f. 14–17; pl. 33. f. 6b.* 1874.

Eucalyptus Geinitzi Heer, Fl. Foss. Arct. 6[2]: 93. *pl. 19. f. 1c; pl. 65. f. 4–9.* 1882. Lesq. Fl. Dak. Group, 138. *pl. 37. f. 20.* 1892. Newb. Fl. Amboy Clays, 110. *pl. 32. f. 2, 12, 15, 16.* 1896. Hollick, Trans. N. Y. Acad. Sci. **11**: 98. *pl. 2. f. 1.* 1892; **12**: 34. *pl. 2. f. 5.* 1892; 236. *pl. 6. f. 2.* 1893; Bull. Geol. Soc. Am. **7**: 13. 1895; Annals N. Y. Acad. Sci. **11**: 60. *pl. 4. f. 1–3.* 1898. White, Am. Jour. Sci. III. **39**: 98. *pl. 2. f. 8–11.* 1890. Heer, Kreide Fl. Moletein, 22. *pl. 11. f. 3, 4.*

This reference is only provisional, as the leaf is too fragmentary for certainty and the venation is entirely obliterated. I have thought I detected the characteristic venation at times but cannot be certain. Previously recorded from the Dakota, Kansas; the Raritan, Woodbridge, Sayreville, N. J.; and the Cretaceous of Staten Island, Long Island and Martha's Vineyard. Also recorded from Greenland and the continent of Europe.

Eucalyptus (?) **dubia** sp. nov. *Pl. 52. f. 1.*

This fragment is referred to *Eucalyptus* because of its resemblance to Newberry's Fl. Amboy Clays, *pl. 32. f. 6,*

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* Although Ettingshausen records them from the Tertiary of New Zealand (Trans. N. Z. Inst. v. 23).

(*E.* (?) *angustifolia*). In all probability neither of these leaves is related to *Eucalyptus*.

The secondaries spring from the midrib at an angle of 45° to 50° and are approximately straight and parallel, about 1.5 mm. apart, some opposite, others irregular; intermediate tertiaries give alternate branches to each secondary. The venation is not characteristic of *Eucalyptus*, and resembles somewhat that of *Laurophyllum reticulatum* Lesq., but our specimen is a smaller, relatively narrower leaf. A second specimen shows a marginal vein connecting the secondaries about .5 mm. from the margin.

STERCULIACEAE.

Sterculia Linn. Sp. Pl. 1007. 1753.

Nearly one hundred existing species of the tropics of both hemispheres. American fossil species are some seventeen in number, distributed as follows: Potomac 1, Cheyenne Sandstone 1, Raritan 1, Island Raritan 2, Dakota 8, Cretaceous of British Columbia 1, Denver 1, Green River 1.

None have been recognized in the Atane beds of Greenland, although one species occurs at Patoot. One species has been recorded from the Island of Sachalin; the genus is present in the upper Cretaceous of Europe and some sixteen species have been described from the European Tertiary deposits, although the American Tertiary is practically barren of these plants.

Sterculia Cliffwoodensis sp. nov. *Pl. 43. f. 5.*

Sterculia sp. (?) Hollick, Trans. N. Y. Acad. Sci. **16**: 133. *pl. 14. f. 4–7.* 1897.

It is to be hoped that more and fuller remains may be discovered of this beautiful species. The present specimen indicates a trilobed leaf with entire margin and decurrent base; lobes diverging at an angle of about 45° or less, with nearly parallel margins and acute tips (?); the secondaries branch at a wide angle and their tips are joined by rather straight arches.

Lesquereux separates the Dakota leaves of *Sterculia* from *Aralia* merely on account of the "primary divisions and primary nerves from the top of the petiole." This character, which I do not consider diagnostic, would refer this leaf to *Aralia* as the lateral primaries branch from the midrib a considerable distance above its base. The venation is somewhat similar to the Dakota *Sterculia reticulata* Lesq. (Fl. Dak. Group, *pl. 34. f. 10*), and also to that of *Aralia transversinervia* Sap. & Mar. described by Hollick from Oakneck, Long Island (Bull. Torrey Club, **21**: 54. *pl. 176. f. 1*. 1894) which leaf he does not consider an *Aralia*.

In outline this leaf resembles *Sterculia lugubris* Lesq. except that the primaries are not basal; whether the lobes were produced to the length they are in that species is of course conjectural. Our fragment is also somewhat similar in outline to the fragment (Fl. Amboy Clays, *pl. 26. f. 2*) referred by Newberry to *Aralia quinquepartita* Lesq., in which however the venation is unfortunately obliterated. Hollick's *Sterculia* sp. (*l. c.*) probably belongs here; his *f. 4* is the fragment of a much smaller leaf, but his larger fragments (*f. 5–7*) might well be the acutely tipped lobes of our leaf, the venation of the two corresponding very well.

Our leaf also has somewhat the appearance of *Aralia Jorgenseni* Heer (Fl. Foss. Arct. **7**: *pl. 101. f. 1*) but the sinuses are not quite so deep. It might further be compared to *Aralia Wellingtoniana Vaughanii* Knowlton from the Woodbine formation of Texas (Dakota). The latter is trilobed, the lobes slender and entire; not figured, however. (Knowlton; Hill, Ann. Rep. U. S. Geol. Surv. **21**: 318. 1901.)

Sterculia Snowii bilobata var. nov. *Pl. 43. f. 7.*

Sterculia Snowii is known from the Dakota Group of Kansas and New Mexico and the Cheyenne Sandstone at Belvidere, Kansas. The specimen from the Matawan here figured, in its outline approximates *Liriophyllum Beckwithii* Lesq., from the Dakota Group, but the venation is radically differ-

ent. We have supposed its relationship to be with *Sterculia Snowii* not only because the latter already has a remarkable bilobate form (var. *disjuncta*), but also because we can readily imagine a leaf like the leaf of *S. Snowii* shown on Fl. Dak. Group, *pl. 33. f. 3* with a deeper sinus which would then make it correspond with our specimen.

This reference is far from satisfactory; it would seem that if this is a variety of *S. Snowii* the latter ought to be present as well or at least in the Raritan, although it has not as yet been discovered, except a doubtful specimen from Tottenville, Staten Island (Hollick, Ann. N. Y. Acad. Sci. **11**: 422. *pl. 37. f. 4.* 1898). Although Lesquereux in his Report on the Clay Deposits of New Jersey (1878) recognized undetermined species of *Sterculia* at three different localities, no decisive remains of this genus have thus far come to light in the Raritan formation in New Jersey. Dr. Hollick, to whom a sketch of this leaf was sent, is disposed to compare it with Fl. Dak. Group, *pl. 21. f. 5*, which Lesquereux refers to Heer's *Cissites formosus*. Inasmuch as Lesquereux's determination is doubtful, because the secondary system is quite unlike that of *Cissites* in looping along the margins and more like that of *Sterculia*, I prefer to consider it more nearly related to the latter, at least provisionally. It may also be compared with *f. 3* of *Aralia concreta* Lesq., as figured by him in Cret. & Tert. Fl. *pl. 9*. *Sterculia limbata* Velen., the Bohemian representative of *S. Snowii*, has sometimes 4-lobed, 4-veined leaves.

STERCULIA MUCRONATA Lesq. *Pl. 43. f. 3.*

Sterculia mucronata Lesq. Fl. Dak. Group, 182. *pl. 30. f. 1–4.* 1892.

In the absence of the apical and basal portions, and because of the obliteration of the venation, it is with considerable hesitation that I refer this small bilobed leaf to the above Dakota Group species. That it is referable to *Sterculia* is I think probable, but just which species to associate it with is doubtful. It is about the same size as Lesquereux's smaller

specimens (*f. 3, 4*), but differs in having the midrib branch at some distance above the base. Both ancient and modern *Sterculia* leaves vary considerably, and *Sterculia Snowii* has a bilobed form.

There is considerable resemblance to the smaller leaves from the Raritan at Woodbridge, which Newberry refers to *Sassafras acutilobum* Lesq. (Fl. Amboy Clays, *pl. 25. f. 2, 5, 6, 10*). Leaves of the living *Sterculia diversifolia occidentalis* Benth., from interior Australia, contained in the Meisner Herbarium, are very similar to *Sterculia mucronata*.

ARALIACEAE.

Aralia Linn. Sp. Pl. 273. 1753.

The genus *Aralia* has never been precisely defined for the paleobotanist, the custom being to follow precedent and refer a variety of polymorphic leaves of synthetic types to this genus—leaves having a variety of affinities, Platanoid, Sassafroid, etc., as well as leaves allied to *Cissus* and *Hedera*. The existing flora includes some twenty-seven species of North America and Asia, six of which are American; only one of these, however (*A. spinosa* L.), is arborescent. The ancient flora contains numerous leaves that have been referred to this genus, besides several that have been referred to the allied genus *Araliaephyllum*. The distribution of the American fossil species is as follows:* Potomac 1, and 4 sp. of *Araliaephyllum*, Raritan 8, Matawan 6, Island Raritan 5, Dakota 13, Mill Creek 3, Laramie 3, Denver 1, Ft. Union 5, Tertiary of Yellowstone Park 3, Green River 1, Eocene 4, Miocene 5, Atane beds 2, Patoot beds 1, Greenland Tertiary 2.

Velenovsky enumerates two species from the Cenomanian of Bohemia, *A. decurrens* being apparently identical with *A. Saportanea* of the Dakota, and the other, *A. coriacea*, reappearing at Martha's Vineyard. From the European Tertiary some thirty-two species are recorded, none occurring in the existing flora of Europe.

* Ettingshausen (Trans. N. Z. Inst. 19: 449) records *Aralia* in the Tasmanian Tertiary.

Lesquereux (Fl. Dak. Group, 249) characterizes these leaves as follows: "Base decurrent, primary nervation palmately trifid and supra-basilar," but he repeatedly fails to conform to his definition. Thus his *A. acerifolia*, *A. tenuinervis*, *A. dissecta* and *A. subemarginata* lack the decurrent base, as do also five of Newberry's Raritan forms. The primaries are generally subbasal and are basal in Lesquereux's *A. quinquepartita*, *A. notata*, *A. dissecta* and *A. Masoni*. I have been at a loss to distinguish between *Sterculia* and *Aralia* in the Matawan material; no mutually exclusive characters can be gathered from the published descriptions or figures, and as it would be useless to attempt a revision without an examination of all the collected material, I have been forced to follow the pernicious precedent above alluded to.

ARALIA TOWNERI Lesq.

Aralia Towneri Lesq. Bull. U. S. Geol. & Geog. Surv. Terr. **1**: 394. 1876; Ann. Rep. *ibid.* **1874**: 349. *pl. 4. f. 3.* 1876; Cret. & Tert. Fl. 62. *pl. 6. f. 4.* 1883; Fl. Dak. Group, 132. *pl. 23. f. 3, 4; pl. 31. f. 1.* 1892. Hollick, Trans. N. Y. Acad. Sci. **16**: 132. *pl. 14. f. 11, 12.* 1897.

Described originally from the Dakota Group of Kansas, Hollick has doubtfully referred two fragments from the clays near Cliffwood to this species. These fragments are so incomplete that the form of the leaf is more or less conjectural. The secondaries are straighter than in Lesquereux's specimens and branch from the primaries at a wider angle. At the same time they seem to differ from my specimens from this formation which I have referred to *Aralia Ravniana* Heer.

ARALIA RAVNIANA Heer. *Pl. 46. f. 7; pl. 53. f. 2; pl. 57. f. 1.*

Aralia Ravniana Heer, Fl. Foss. Arct. **6**[2]: 84. *pl. 38. f. 1, 2.* 1882.

The specimens from Cliffwood figured above are identical with Heer's *Aralia Ravniana* from the Atane schists at

Igdlokunguak, Greenland, except that the basal primary forks a considerable distance from its base. I was at first disposed to refer them to *Aralia Towneri* Lesq., particularly as Heer compared his leaves with that species and Lesquereux suggested * that the two were identical.

While the occurrence of two such large-leaved species of *Aralia* in the Matawan formation may seem anomalous, especially as they had much in common, I fail to see their identity. *Aralia Towneri* was a palmately five-lobed leaf with a decurrent base and obtuse lanceolate lobes. *Aralia Ravniana* on the other hand was probably a six- or seven-lobed leaf of large size, for while in no case is the apex preserved, I cannot conceive that such a leaf as the discovered fragments evidently represent could have had an undivided terminal lobe. If they had, they would differ from all other species of *Aralia* in its size, and from lobed leaves in general. They would have had a lobe wider than long, with an area greater than the balance of the leaf, the deep lateral sinuses almost cutting it off from the rest of the blade. In the specimen figured at *pl. 57, f. 1* (one fourth natural size) the midrib more than half way to the tip gives off a strong lateral branch which it seems reasonable to suppose formed the midrib of a lateral lobe. Furthermore, *A. Ravniana* differs from *A. Towneri* in having stouter primaries, narrower sinuses, more ovate lobes, the basal ones widely spreading, and the base but slightly or not at all decurrent. If we may judge from the obsolete venation, it was a more coriaceous leaf.

Aralia palmata Newb. *Pl. 44.*

Aralia palmata Newb. Fl. Amboy Clays, 117. *pl. 39. f. 6, 7; pl. 40. f. 3.* 1896.

It is easier perhaps to criticise others than to escape criticism oneself, at the same time in considering the leaves which seem referable to *Aralia* in our collections from near Cliffwood and in comparing them with the Raritan forms referred

* Cret. & Tert. Fl. 105.

to this genus by Newberry, we are struck with the range of variability, not only within each species as defined by him, but in the whole group, and the thought forces itself upon us that perhaps it would be an advantage to cut down the total number of species. Newberry has described seven species from the Woodbridge horizon alone and only one from the higher beds at South Amboy. The occurrence of a variety of *Aralia*-like leaves in the Matawan shows that the imperfection of the record is probably responsible for their absence in the intervening beds: and it seems rather incredible that each form represents an ancient species that flourished on the New Jersey coast in Cretaceous days.

The leaves before us, while not uniform, seem to more nearly represent *Aralia palmata* than any other known form. Our *f. 5* may be compared with Newberry's *f. 6*. While it is about one sixth smaller, other fragments from Cliffwood indicate a somewhat larger size; the lobes are a trifle more slender and the main sinuses somewhat deeper. The lower margins were sometimes undulate and the latero-basal lobes short. The lobation was, however, somewhat variable, as it was also in Newberry's leaves. Our *f. 6* might be compared with a variety of forms, such as *Ficus* (?) *Alaskana* Newb. (Later Ext. Fl. *pl. 51. f. 1*) and *Hedera obliqua* Newb. or *Hedera primordialis* Newb. of the Amboy Clays. It has the secondaries straighter than is usually the case in this genus; in its tertiary venation it agrees with Newberry's *f. 3* of *Aralia palmata*. The secondaries were distant and were joined at their tip by widely arching loops.

Other species with which our leaves may be compared are *Cissites ingens* Lesq. and *Liquidambar integrifolium* Lesq. (Cret. and Tert. Fl. *pl. 14. f. 3*).

Aralia Groenlandica Heer. *Pl. 45. f. 4.*

Aralia Groenlandica Heer, Fl. Foss. Arct. 6^2: 84. *pl. 38. f. 3; pl. 39. f. 1; pl. 46. f. 16, 17.* 1882 (*f. 17* is *Aralia Ravniana*); *pl. 39. f. 3* of *Sassafras recurvatum* Lesq. is in all probability this species. Lesq. Fl. Dak.

Group, 134. *pl. 54. f. 1–3.* 1892. Hollick, Bull. Geol. Soc. Am. 7: 13. 1895. Newb. Fl. Amboy Clays, 116. *pl. 28. f. 4.* 1896.

A widespread species recorded from the Atane schists, Greenland; Dakota Group, Kansas; Raritan, Woodbridge, N. J.; and the Cretaceous at Martha's Vineyard.

If Newberry has correctly identified Fl. Amboy Clays, *pl. 28, f. 4*, as the above species then our fragment undoubtedly belongs to the same species. It is the same size as Newberry's leaf; the angle of divergence of the lateral primaries is a trifle greater however, and the primary venation is stronger, agreeing with Lesquereux's and Heer's leaves in the latter particular. Both the New Jersey leaves are smaller than the Dakota and Greenland specimens and have relatively narrower lobes. Unfortunately the basal portion of the Cliffwood leaf is gone, so we do not know whether or not there was an extra pair of laterals springing from the base of the midrib. This is a feature of all the leaves which Lesquereux has referred to this species, but is wanting in Heer's *pl. 38, f. 3*, and is also wanting on one side in the Raritan leaf.

The leaf which Newberry describes as a new species (*l. c.* 117. *pl. 28. f. 3*), under the name of *Aralia patens*, should in all probability be considered as a form of his *A. Groenlandica* with deeper sinuses and more divergent lobes, as he suggests. Our leaf might also be compared with Cret. & Tert. Flora, *pl. 5. f. 1*, which Lesquereux considers *Sassafras acutilobum;* it is also much the same form of leaf as *Sterculia aperta* Lesq., but larger; and there is considerable resemblance to the leaf which Heer refers to *Sassafras Ferretiana* Mass. (Fl. Foss. Arct. 7: *pl. 97. f. 5*).

Aralia Mattewanensis sp. nov. *Pl. 43. f. 2; pl. 46. f. 6.*

A palmately four- or five-lobed leaf; lobes oblanceolate in outline (tips missing), with rather narrow sinuses nearly to the base; primaries rather stout; a majority of the secondaries branch at a wide angle and are nearly straight to within a short distance of the margin, along which they arch. Leaf coriaceous, if we may so judge from the obsolete venation.

These leaves have a distant resemblance to Lesquereux's *Cissites formosus* Heer (Fl. Dak. Group, *pl. 21. f. 5*) but bear no resemblance to the Amboy Clay leaves which Newberry refers to that species. Our leaves also suggest some forms of *Aralia* such as *A. quinquepartita* Lesq., but the base is apparently not decurrent and the primaries branch from the midrib at the same place, the lateral ones at nearly right angles.

Aralia Brittoniana sp. nov. *Pl. 45. f. 3.*

I have been unable to identify this with any known species of *Aralia* and therefore add another to the long list of diversified leaves of this genus which have been found in the Raritan and Matawan formation. In size and outline it resembles *Aralia acerifolia* Lesq. of the Fort Union beds of the West, but the secondaries are stronger and more regular. The specimen denotes a leaf which was trilobed with an evident tendency to produce an extra latero-basal lobe on each side; with a broadly truncated base which curves upward for about half the distance to the tip to form a point above which the margin is concave; lobes presumably acute; terminal lobe broad with moderately convex sides; sinus to below the middle, rounded; primary and secondary venation strong, but tertiary venation entirely obsolete; lateral primary could not have branched far from the base and forms an angle of about 45° with the midrib, leaving room for a secondary below; secondaries regular, leaving the primaries at a wide angle and running straight to within a short distance of the margin and then curving to join the secondary next above. Our only specimen was evidently not bilaterally symmetrical.

ERICACEAE.

ANDROMEDA Linn. Sp. Pl. 393. 1753.

At the present time a monotypic genus of the north temperate and subarctic zone. Many fossil leaves have been referred here, some twenty-five species in this country alone.

The generic determination of Ericaceous leaves is always however a matter of extreme uncertainty, which is fully shared by the following distributed American forms: Raritan 6, Island Raritan 1, Dakota 9, Woodbine 1, Montana 1, Laramie 2, Livingston 1, Denver 1, Green River 2, Eocene 2, Miocene 1, Pleistocene 2, Atane 2, Greenland Tertiary 5.

ANDROMEDA PARLATORII Heer. *Pl. 50. f. 1–4.*

Andromeda Parlatorii Heer, Phyll. Crét. Nebr. 18. *pl. 1. f. 5.* 1866. Lesq. Cret. Flora, 88. *pl. 23. f. 6, 7; pl. 28. f. 15.* 1874; Fl. Dak. Group, 115. *pl. 19. f. 1; pl. 52. f. 6.* 1893. Newb. Fl. Amboy Clays, 120. *pl. 31. f. 1–7; pl. 33. f. 1, 2, 4, 5.* 1896. Heer, Fl. Foss. Arct. **3**: 112. *pl. 32. f. 1, 2.* 1875; **6**[2]: 79. *pl. 21. f. 1b, 11; pl. 42. f. 4c.* 1882. Hollick, Bull. Torrey Club, **21**: 54. *pl. 175. f. 2, 5.* 1894; Ann. N. Y. Acad. Sci. **11**: 420. *pl. 37. f. 7.* 1898. White, Am. Jour. Sci. III. **39**: 97. *pl. 2. f. 4.* 1890.

Prunus ? Parlatorii Lesq. Am. Jour. Sci. II. **46**: 102. 1868.

This species is recorded from the following localities: Dakota Group: Kansas, Nebraska, and New Ulm, Minn. Cretaceous: Sea Cliff, L. I., Tottenville, Staten Island and Martha's Vineyard. Raritan: common at nearly every locality opened. Greenland: Atane beds at Atanekerdluk, Isunguak and Igdlokunguak.

Newberry (*l. c.*) is inclined to doubt the reference of all these leaves to *Andromeda*, pointing out that generic determinations of most Ericaceous leaves are always doubtful. Heer compares his Greenland specimens to Ettingshausen's *Laurus cretacea* from Niederschöna. In our *f. 4* the finer reticulation is very minute and five- or six-sided.

MYRSINACEAE.

MYRSINE Linn. Sp. Pl. 196. 1753.

Fossil American species occur in the following formations: Raritan 3, Island Raritan 3, Dakota 2, Green River 1, Atane 1, Greenland Tertiary 2.

The family is a large one of the tropics of both hemispheres. In the recent monographic revision by Carl Mez (Engler, Pflanzenreich, Heft 9, 1902) nine hundred and thirty-three species are enumerated distributed among thirty-two genera and nine fossil genera are enumerated. Four species, all arborescent, enter the United States, one of them a true *Myrsine*, the others referred to the genera *Icacorea* (*Ardisia*) and *Jacquinia*. They range from southern Florida through the West Indies, Central America, Mexico and northern South America.

MYRSINE CRASSA Lesq. *Pl. 52. f. 6.*

Myrsine crassa Lesq. Fl. Dak. Group, 114. *pl. 52. f. 2, 3.* 1892.

The single leaf which I have referred to this Dakota species was lost after the hurried sketch which is here reproduced was made and the reference can therefore be only provisional unless additional specimens are discovered.

The outline and venation suggest this species although it is a somewhat smaller leaf. I was at first inclined to refer it to *Liriodendropsis*, which it greatly resembles, but in the absence of the apex our reference of it to this species of *Myrsine* is warranted.

OF UNCERTAIN AFFINITIES.

DEWALQUEA GROENLANDICA Heer (?). *Pl. 57. f. 3.*

Dewalquea Groenlandica Heer, Fl. Foss. Arct. 6[2]: 87. *pl. 29. f. 18, 19; pl. 42. f. 5, 6; pl. 44. f. 11;* 7: 37. *pl. 62. f. 5, 6.* Newb. Fl. Amboy Clays, 129. *pl. 41. f. 2, 3, 12.* 1896. Hollick, Ann. N. Y. Acad. Sci. **11**: 423. *pl. 36. f. 7.* 1898.

Obscure leaf-remains of uncertain botanical affinities; included by Heer in the Ranunculaceae. Leaves (or leaflets) with very tapering base, thick midribs, and short petioles; apparently rather coriaceous in texture and with the venation entirely obliterated. They agree fairly well with the figures of this species as cited above. This is another species which

occurs in the New Jersey Raritan (localities not given); on Staten Island; and in the Atane and Patoot beds of Greenland. The genus was founded by Saporta & Marion* and embraces several European species of which *Dewalquea insignis* reappears in both the Atane and Patoot beds of Greenland, and on Staten Island; while *D. Haldemiana* reappears in the Patoot beds, in Utah, and on Staten Island. The Dakota group furnishes two additional species.

PODOZAMITES MARGINATUS Heer. *Pl. 46. f. 1–3.*

Podozamites marginatüs Heer, Fl. Foss. Arct. 6^2: 43. *pl. 16. f. 10.*

Similar remains are common in the Raritan (three species). Hollick (Bull. Torrey Club, **21**: 62. *pl. 180. f. 4*) records a fragment from Glen Cove, Long Island, and also from Chappaquidick Island, Mass. (Bull. N. Y. Bot. Gard. **2**: 401. *pl. 41. f. 8, 9.* 1902).

The genus was founded by Fr. Braun, in Münster, Beitr. Petrefacten-Kunde (Heft. 6. 28. 1843) and is chiefly Upper Triassic (Rhetic) and Jurassic, becoming decadent in the Cretaceous. The latter has yielded, however, seventeen species on this continent (including Greenland), nine of which existed as late as the mid-Cretaceous, all described from rather fragmentary and somewhat doubtful leaf-remains.

Our specimens would appear to be fragments of *Podozamites marginatus?* Heer, which occurs at Woodbridge in the Raritan clays (Fl. Amboy Clays, 44. *pl. 13. f. 5. 6*); originally described by Heer from Atane, Greenland.

Phragmites (?) **Cliffwoodensis** sp. nov. *Pl. 46. f. 5.*

A terminal, sharply pointed fragment of a monocotyledonous leaf, 12 cm. long and 5.5 mm. broad, finely parallel-veined.

The remains of *Phragmites* usually consists of leaf fragments or rhizomes, all of rather doubtful affinity, although a single palet of *P. Oeningensis* A. Br. is described by Heer from Greenland.

***Mem. Cour. & Sav. Étrangers Acad. Belg. 37 : 55. 1873.**

The Matawan remains are too small to be definitely referred to *Phragmites*, and may be compared to those referred to *Poacites*, *Cyperites*, etc.

CHONDRITES FLEXUOSUS Newb. (?)

Chondrites flexuosus Newb. Fl. Amboy Clays, 34. *pl. 1. f. 1, 4.* 1896.

Obscure remains from near Clifford (not figured), of doubtful botanical affinities, may be compared with the above species which occurs at Sayreville, Woodbridge, etc., in the Raritan clays.

Carpolithus juglandiformis sp. nov. *Pl. 46. f. 8.*

Has a superficial resemblance, but no botanical affinity with some of the fruits referred to the genus *Cycadeospermum*. Is evidently not a seed-bearing scale but seems to have been a small nutlet which has been compressed and transformed into lignite; bears considerable resemblance to *Juglans costata* (Presl) Brongn. as figured by Lesquereux (Cret. & Tert. Fl. *pl. 39. f. 5*) from the Green River group at Florissant, Colorado.

Carpolithus Cliffwoodensis sp. nov. *Pl. 48. f. 6.*

This specimen resembles a number of seeds figured by Heer from the Arctic regions, as for instance *Lamprocarpites nitidus* (Fl. Foss. Arct. 6^2: *pl. 8. f. 12–14*) and *Carpolithes najadium* (*ibid.* 1: *pl. 27. f. 15, 15b*), although with the exception of *f. 14* our specimens are about twice the size of any of those of Heer.

Carpolithus dubius sp. nov. *Pl. 48. f. 7.*

This appears to be a thick, inequilateral, oblong scale. It is about 2 mm. in thickness and the surface is irregularly roughly lined. Botanical affinity vague.

CARPOLITHUS VIRGINIENSIS Font. (?) *Pl. 48. f. 5.*

Carpolithus Virginiensis Font. Potomac Flora, 266. *pl. 134. f. 11–14; pl. 135. f. 1, 5; pl. 168. f. 7, 7a.*

1889. Ward, Ann. Rep. U. S. Geol. Surv. **19**[2]: 693. *pl. 169. f. 16.* 1899.

Without a comparison of specimens this reference is only provisional, although from the published figures our specimen is almost exactly like the detached specimens from the Potomac formation described as above. Fontaine considers them as probably belonging to some species of *Baieropsis*, a Lower Cretaceous genus which does not occur in New Jersey; nor is it at all likely to have persisted as late as the Middle Cretaceous. Remains are abundant in the Potomac formation attached to stems; also found detached in the Lower Cretaceous of the Black Hills; and in the Kootanie at Great Falls, Montana. Remains indicate a small, smooth, and hard nutlet.

CARPOLITHUS DRUPAEFORMIS Hollick.

Carpolithus drupaeformis Hollick, Trans. N. Y. Acad. Sci. **16**: 134. *pl. 11. f. 4, 4a.* 1897.

Apparently the seed of some drupaceous fruit as the name indicates. Recorded by Hollick from the Matawan formation near Cliffwood, N. J.; not found by me.

STROBILITES INQUIRENDUS Hollick.

Strobilites inquirendus Hollick, Trans. N. Y. Acad. Sci. **16**: 130. *pl. 11. f. 1.* 1897.

Remains of doubtful affinity, possibly a distorted and somewhat macerated cone. Recorded by Hollick from the Matawan formation near Cliffwood, N. J.; not found by me.

PITYOXYLON HOLLICKI Knowlton.

Pityoxylon Hollicki Knowlton; Hollick, Trans. N. Y. Acad. Sci. **16**: 134. *f. 1, 2.* 1897.

Recorded by Hollick from the Matawan formation near Cliffwood, N. J.; not found by me.

Description of Plates.

PLATE 43.

Fig. 1. *Nelumbo primaeva* sp. nov.
Fig. 2. *Aralia Mattewanensis* sp. nov.
Fig. 3. *Sterculia mucronata* Lesq.
Fig. 4. *Moriconia cyclotoxon* Deb. & Ett.
Fig. 5. *Sterculia Cliffwoodensis* sp. nov.
Fig. 6. *Celastrophyllum elegans* sp. nov.
Fig. 7. *Sterculia Snowii bilobata* var. nov.

PLATE 44.

Aralia palmata Newb.

PLATE 45.

Figs. 1, 2. *Sassafras acutilobum* Lesq.
Fig. 3. *Aralia Brittoniana* sp. nov.
Fig. 4. *Aralia Groenlandica* Heer.

PLATE 46.

Figs. 1–3. *Podozamites marginatus* Heer.
Fig. 4. *Arisaema cretaceum* Lesq.
Fig. 5. *Phragmites* (?) *Cliffwoodensis* sp. nov.
Fig. 6. *Aralia Mattewanensis* sp. nov.
Fig. 7. *Aralia Ravniana* Heer.
Fig. 8. *Carpolithus juglandiformis* sp. nov.

PLATE 47.

Figs. 1, 5, 8. *Laurophyllum angustifolium* Newb.
Figs. 2, 3. *Sapindus Morrisoni* Lesq.
Fig. 4. *Magnolia obtusata* Heer.
Fig. 6. *Quercus* sp.
Fig. 7. *Ficus Woolsoni* Newb.
Fig. 9. *Laurus proteaefolia* Lesq.
Fig. 10. *Magnolia tenuifolia* Lesq.

PLATE 48.

Figs. 1–4. *Moriconia cyclotoxon* Deb. & Ett.
Fig. 5. *Carpolithus Virginiensis* Font. (?).
Fig. 6. *C. Cliffwoodensis* sp. nov.
Fig. 7. *C. dubius* sp. nov.
Figs. 8–11. *Dammara Cliffwoodensis* Hollick.
Fig. 12. *Salix proteaefolia flexuosa* (Newb.) Lesq.
Fig. 13. *Quercus Holmesii* Lesq.
Figs. 14, 19. *Cunninghamites squamosus* Heer.
Figs. 15, 16, 17, 20. *Sequoia Reichenbachi* (Gein.) Heer.
Fig. 18. *Sequoia Reichenbachi* (Gein.) Heer. (?).
Figs. 21–22. *Sequoia gracillima* (Lesq.) Newb.

PLATE 49.

Figs. 1–5. *Laurophyllum angustifolium* Newb.
Fig. 6. *Laurus proteaefolia* Lesq.
Fig. 7. *Populites tenuifolius* sp. nov.

PLATE 50.

Figs. 1–4. *Andromeda Parlatorii* Herr.
Figs. 5, 6. *Rhamnus Novae-Caesareae* sp. nov.
Figs. 7, 8. *Laurus Hollae* Heer.
Figs. 9–11. *Laurus Plutonia* Heer.

PLATE 51.

Figs. 1, 2. *Quercus Hollickii* sp. nov.
Fig. 3. Undetermined.
Fig. 4. *Quercus* (?) *Novae-Caesareae* Hollick.
Fig. 5. *Salix Mattewanensis* sp. nov.
Figs. 6–9. *Proteoides daphnogenioides* Heer.

PLATE 52.

Fig. 1. *Eucalyptus* (?) *dubia* sp. nov.
Fig. 2. *Salix proteaefolia flexuosa* (Newb.) Lesq
Fig. 3. Undetermined.
Fig. 4. *Laurus Hollickii* sp. nov.
Fig. 5. *Ficus reticulata* (Lesq.) Knowlton.
Fig. 6. *Myrsine crassa* Lesq.
Figs. 7, 8. *Laurus Hollae* Heer.
Fig. 9. *Quercus* sp.

PLATE 53.

Figs. 1, 4. *Ficus reticulata* (Lesq.) Knowlton.
Fig. 2. *Aralia Ravniana* Heer.
Fig. 3. *Eucalyptus Geinitzi* Heer.
Fig. 5. *Magnolia Woodbridgensis* Hollick.

PLATE 54.

Boulders of clay on beach near Cliffwood, N. J., yielding plant remains.

PLATE 55.

Showing how face of bluff near Cliffwood, N. J., is obscured by landslips.

PLATE 56.

View of bluff near Cliffwood, N. J., showing alternating layers of sand and lignite.

PLATE 57.

Fig. 1. *Aralia Ravniana* Heer. Cliffwood specimen restored, ¼ natural size.
Fig. 2. *Magnolia Woodbridgensis* Hollick.
Fig. 3. *Dewalquea Groenlandica* Heer. (?)

Bolivian Mosses. Part I.

By R. S. Williams.

The following list of mosses includes species collected by the author while attached to a party in charge of Dr. John W. Evans, sent out to Bolivia for the purpose of exploring certain regions on tributaries of the upper Amazon for The Bolivia Company. Our party landed early in August, 1901, at Mollendo, passed through Peru and over Lake Titicaca, first to La Paz, reaching that city August 13, where we remained some days making farther preparations for the trip. From La Paz, 3500 meters elevation, we went to the town of Sorata, 1200 meters lower, then over several high passes of the Cordillera Real, the highest attaining an altitude of about 4860 meters, by way of Ingenio and Tolapampa, to Mapiri on the Mapiri River with an elevation of only 485 meters. Here we obtained balsas and floated down the Mapiri and Beni Rivers to San Buena Ventura, 430 meters elevation and the lowest point reached on the trip. Leaving the river at this point we went to the westward, visiting the towns of Tumupasa, San José and Ixiamas, in the lower forest region, then going to Apolo, a town situated at 1440 meters elevation in an open, nearly treeless valley, with low, grass-covered mountains on either side. We remained here from the middle of February, 1902, until the latter part of April, making one trip, meanwhile, northwestward through forests to the Lanca river, which occupied nearly a month's time. April 24, we left Apolo for La Paz by way of the Pelichuco Pass, quite a number of miles to the northward of the Sorata-Mapiri trail, and passed through the towns of Santa Cruz, Pata and Pelichuco in Bolivia and Cojata, Taraco, Juliaca and Puno, on the high tableland of Peru, about 3950 meters elevation. From Puno, the railway station on Titicaca, our route was the same as that first traversed to La Paz. Shortly after reaching that city, instead of returning home at once, two

members of our party, Mr. John Turle and the author, went back to Apolo where we remained until September. On this second trip to the interior we went from La Paz to Sorata as before, but shortly after leaving that place, kept somewhat to the left of our first route and quite near to the Sorata River, passing through Tacacoma and Consata and striking the Mapiri-Apolo trail some fifteen miles from Mapiri at Achiquiri. Reaching Apolo the second time June 20, we remained till near the middle of September, exploring the adjacent region, especially that about Atten to the southwest, and Santa Cruz, to the northward. September 13 we again started for La Paz going by way of the Mapiri-Sorata trail, over roads already essentially traversed. The altitudes given are largely estimates, to be considered as only approximately correct. In the arrangement of species I have followed Brotherus in Engler & Prantl.

ANDREAEA STRIATA Mitt.

Common at 4200 or 4500 meters in the vicinity of Sorata, also collected near Ingenio, Tolapampa and Tacacoma. This species seems to vary in much the same manner as *A. petrophila*. The tufts measure up to 4 cm. high, with leaves from very papillose to nearly smooth (1680 to 1685).

TREMATODON REFLEXUS C. Müll.

On mud banks along the Mapiri river, 450 meters. In fine fruit, April 26, Tuichi river. The collum may be distinctly strumose at base or without struma (1852, 1853 and 2855).

DITRICHUM RUFESCENS Hampe.

Below Pelichuco, 2600 meters, on rock, April 30, 1902 (2827).

CERATODON NOVOGRANATENSIS Hampe.

Pelichuco, 3500 meters, May 3, 1902 (2876).

DISTICHIUM CAPILLACEUM (Sw.) Bry. Eur.

Luipichi Pass, above Sorata, 4200 meters, on rock, September 27, 1902 (1709).

Dicranella Apolensis sp. nov.

Dioicous. Slender stems up to 2.5 cm. high, with few branches: leaves lanceolate, falcate-secund, keeled, somewhat revolute at margin, mostly acutely pointed, entire except at apex, which often terminates in 2 or 3 teeth of about equal length; costa vanishing just below apex, well defined below and scarcely one fourth the width of the leaf-base; stem-leaves 1.5 mm. long, perichaetial leaves very similar but a little longer (2 mm.) and more slender-pointed; leaf-cells quite uniform throughout leaf, mostly rectangular, from slightly elongated to two and one half times longer than broad: seta 4 mm. long; capsule erect, ovate, small-mouthed and smooth, 0.75 mm. long, the lid with obliquely rostrate beak about the same length; exothecal cells mostly one and one half to two times longer than broad with thick not sinuous walls; annulus large; teeth pale and irregular, papillose, often split nearly to base or cribrose, with points free or united: spores rough, up to 18 μ in diameter.

On sand along stream, Apolo, July 1, 1902 (1743).

DICRANELLA KUNZEANA (C. Müll) Mitt.

Consata, 900 meters, June 13, 1902 (1740); Tumupasa, 5400 meters, January 25, 1902 (1736). Determined from description only.

Dicranella subserrulata sp. nov.

Apparently dioicous. Stems 2 mm. high: leaves spreading, flexuous, the upper 2.5 mm. long, narrowly elongated-lanceolate, keeled, acute and rather sharply dentate at apex, margin nearly flat and distinctly serrulate about one third down; leaf-lamina pale brown, distinct to apex, larger cells of upper leaf about $5 \times 15\,\mu$, of lower leaf $12 \times 50\,\mu$; costa nearly percurrent, very distinct to base, 50–60 μ wide below and about one fourth the width of the leaf-base: seta up to 8 mm. high; capsule oblong, nearly erect, smooth and wide-mouthed when dry and empty, with conical, obliquely beaked lid often exceeding it in length; teeth of peristome regular, divided three fourths down with slender, red, papillose segments; annulus large: spores, slightly rough, up to 16 μ in diameter.

On sandy cut-bank, Huainachoirisa river, July 28, 1902 (1741). The two preceding species clearly belong to the subgenus *Microdus*, while this has the peristome rather of a true *Dicranella*.

DICRANELLA TENUIROSTRIS (Kunze) Mitt.

Common about Apolo, 1440 meters, April, June and August (1726, 1739, 1744); Lanca river, 900 meters, March (1731).

These specimens are similar to Spruce's no. 39 and no. 43, called *D. exigua*, but are not the *D. exigua* collected by Beyrich in the Serra d'Estrella, the type locality. This last is a rather smaller plant with shorter and straight, erect-spreading leaves. *D. weissioidea* C. M. (E. Ule no. 6 and no. 61, Bryotheca Brasil.) is evidently this latter species (*D. exigua*).

DICRANELLA BEYRICHIANA Hampe.

Apolo, very common, February to July (1732, 1733, 1734, 1735 and 1745); Mapiri, September, 1901 (1728).

DICRANELLA PERROTTETII (Mont.) Mitt.

Santa Cruz, 1520 meters, April 25, 1902 (2752). These specimens have the capsule often pendant and the seta rather more thickened next to the capsule, than perhaps is usual.

DICRANELLA MACROSTOMA (C. Müll.) Par.

Near La Paz, 3600 meters, August 24, 1901. Determined from description only (2858).

DICRANELLA JAMESONI (Tayl.) Broth.

On wet rock walls, Sorata, 2250 meters, June 6, 1902 (1708).

Campylopodium sulcatum sp. nov.

Dioicous. Densely cespitose: stems 2 cm. high, branching, with radicles at base: stem-leaves up to 4.5 mm. long, lanceolate to ovate-lanceolate, with a long straight subulate point, with incurved margins, entire except the denticulate apex; costa occupying about one half the width of the leaf-base, up to 160 μ wide at insertion, widening above for a short distance, filling most of the subula and becoming excurrent; perichaetial leaves shorter than stem-leaves and rather abruptly narrowed to point; cells of lower leaf-blade pale and thin-walled, those near costa rectangular and broad, becoming narrower toward margin, with 4 or 5 rows of very narrow, long cells in margin: seta up to 1.5 cm. high, only

slightly sinuous, with capsule erect when dry, becoming doubly bent with moisture and capsule more or less nodding; capsule oblong, about 2 mm. in length, very narrow and deeply furrowed when dry, with a high-conical, obliquely rostrate lid two thirds as long; exothecal cells rather irregular, narrow, mostly 4 or 5 times longer than broad with much thickened, somewhat sinuous lateral walls and very thin end-walls; peristome of dark red teeth strongly cross-barred and vertically striate below, divided about one-half down, the slender segments pale and papillose; annulus large: spores pale, smooth, up to 12 μ in diameter.

On decayed log, at about 2700 meters, below Tolapampa on Sorata-Mapiri trail, September 12, 1901 (1756).

Rhabdoweisia fugax (Hedw.) Bry. Eur.

Pelichuco, 3100 meters, May 3, 1902 (2863).

Oreoweisia ligularis Mitt.

On rock walls, above Tacacoma, 3600 meters, June 9, 1902 (1719); Pelichuco, 3300 meters (2871); near Sorata, 3900 meters (2135).

Holomitrium crispulum Mart.

On trunks of trees and fallen logs at 1800 meters. New Brazil, June 14, 1902 (1771); also near Apolo.

Dicranum Bolivianum C. Müll.

Cargadira, Apolo region, 2400 meters, July 31, 1902 (1746); near Pelichuco, 2700 meters (2833).

Campylopus leucognoodes (C. Müll.) Par.

Pelichuco, 3500 meters, May 5, 1902 (2834); Ingenio, 3000 meters, September, 1901 (1757). I first referred these specimens to *C. areodictyon* as they agree well with the description given by Mitten and are evidently the same as those of J. Weir, no. 180; but they differ from the specimens collected by Funck and Schlim in Venezuela, which have a more slender, excurrent, denticulate costa and longer pedicel.

Campylopus densicoma (C. Müll.) Par.

On stump of tree, Pelichuco, 3000 meters, April 30, 1902 (2832).

Campylopus occultus Mitt.

Cargadira, Apolo region, 2400 meters, July 29, 1902 (1754).

CAMPYLOPUS CONCOLOR (Hook.) Mitt.

On logs, Tigre Pata, 1800 meters, San José-Apolo trail, February 10, 1902; Pelichuco, 2700 meters, April 30, 1902 (1748 and 2831).

CAMPYLOPUS ZYGODONTICARPUS (C. Müll.) Par.

Near Apolo, 1650 meters, August 31, 1902 (1758).

CAMPYLOPUS ERECTUS (C. Müll.) Mitt.

On bushes growing on the high hills back of Mollendo, August 5, 1901. Sterile specimens; determined from description (2885).

Campylopus (*Trichophyllii*) **Ingeniensis** sp. nov.

Plants robust, dark chestnut-colored, only the tips of branches sometimes golden-orange, in large mats with irregularly branching, procumbent stems up to 10 cm. long: leaves quite uniformly placed along stems, closely imbricated, erect when dry, with points sometimes recurved; leaf-base ovate-lanceolate, gradually narrowed to subula with incurved margins and bearing a hyaline, serrulate, grooved hair-point sometimes nearly as long as blade, the hyaline serrulate margin extending down on either side some distance below apex of the colored nerve; cross-section of leaf shows 3 or 4 cells at middle of upper surface of costa with somewhat thin walls, all the rest being quite uniformly thickened; the numerous lamellae on back of leaf are mostly 2 cells high; alar cells finally red and somewhat inflated, not forming distinct auricles, cells just above in leaf-blade oblique, narrow, with walls irregularly thickened and pitted: seta 4 mm. high, more or less erect when dry, bent nearly double when moist; capsule oval, furrowed when dry, 1 mm. long, somewhat mammillose at base, with convex, obliquely rostrate lid three fifths as long; annulus large; peristome of solid red teeth with broad base (0.05–0.06 mm.) and divided scarcely one half down; calyptra fringed at base: spores pale, somewhat rough, up to 20 μ in diameter.

On rock near Ingenio, 3600 meters, September 26, 1902 (1772).

CAMPYLOPUS INTROFLEXUS (Hedw.) Mitt.

Santa Cruz, August 25, 1902, 1500 meters (1765).

CAMPYLOPUS PENICILLATUS (Hornsch.) Jaeg.

Near Atten, 1650 meters, June 19, 1902 (1747).

Campylopus (*Rigidi*) **Pelichucensis** sp. nov.

Plants robust, loosely cespitose: stems up to 5 cm. high, with few branches, radiculose to apex: leaves more or less spreading and falcate when dry, narrowly lanceolate, up to 5.5 mm. long and 0.6 mm. wide, serrulate on margin and on back toward apex; cross-sections of costa show rather ill-defined stereid bands in upper and under portions; costa one third the width of the leaf-base, scarcely or very shortly excurrent, with lamellae on back serrulate in upper half; alar cells enlarged and hyaline, finally becoming red and inflated, the cells just above rhomboidal to rectangular, with thickened and pitted walls; inner perichaetial leaves about the same size as stem-leaves but more abruptly narrowed to longer excurrent nerve, the outer leaves often with a few blunt teeth at base of subula: seta straight or somewhat curved when wet or dry, 8 mm. long; capsule 1.75 mm. long, nearly erect, slightly curved and sometimes a little strumose, furrowed, with obliquely-beaked lid two thirds as long: teeth 0.06 mm. wide at base, pale and papillose above, split a little over one half down; annulus large; calyptra fringed at base: spores slightly roughened, up to 15 μ in diameter.

On logs, Pelichuco river, 1800 meters, April 28, 1902 (2835); Santa Anna, July 29 (1751).

Campylopus humilis Mont.

On decayed log, near Pata, 1800 meters, April 26, 1902 (2829). Determined from the brief description only. Montagne remarks that he was unable to find the operculum, although he describes the calyptra with cilia. Brotherus classes the species as one not having the calyptra ciliate, as in my specimens.

Campylopus chrysodictyon (Hampe) Mitt.

Pelichuco, 3300 meters, April 30, 1902 (2830).

Campylopus porphyreodictyon (C. Müll.) Mitt.

Near Atten, 1800 meters, August 5, 1902 (1759, 1768).

Campylopus filifolius (Hornsch.) Mitt.

Consata, 900 meters, June (1766); New Brazil, 1500 meters, June 14, 1902 (1767, 1768).

Campylopus (*Rectiseti*) **subcubitus** sp. nov.

Stems flexuous, more or less reclining, tomentose nearly to apex, up to 7 cm. high, with few branches: leaves falcate-secund, narrowly lanceolate, sharply dentate toward apex on back and margin and serrulate about one half down on margins, up to 6 mm. long and 0.7 mm. wide; upper stem-leaves with hyaline, scarcely inflated alar cells, lower leaves with inflated, deep red alar cells forming conspicuous auricles; cells just above the alar with thin walls not pitted, soon becoming narrower upward with thickened pitted walls; costa one third to two fifths the width of the leaf-base, shortly excurrent with serrulate lamellae on back; cross-sections of leaf show about 13 guide-cells with stereid bands above and below and lamellae on back 1 cell high: seta up to 12 mm. high, straight or somewhat flexuous; capsule 2 mm. long, strumose and somewhat mammillose at base, slightly curved, with an obliquely beaked lid two thirds as long; calyptra ciliate at base: spores up to 16 μ in diameter.

Lower Sorata river, 1200 meters, June 13, 1902 (1749).

Campylopus leptodus (Mont.) Mitt.

Near Paradiso, San José-Apolo trail, 1800 meters, February 12, 1902 (1763).

Campylopus Richardi (Schwaegr.) Mitt.

Cargadira, 2400 meters, July 29, 1902 (1760).

Pilopogon gracilis Brid.

Near Paradiso, 1400 meters, February 12, 1902 (1762); Tolapampa, 4000 meters, September 11, 1901 (1761).

Metzleria longiseta (Hook.) Broth.

Paradiso, 1800 meters, San José-Apolo trail, February 12, 1902 (1755). A rather small form of the species.

Ochrobryum obtusifolium Mitt.

Santa Anna, Apolo region, 1050 meters, on decayed log, July 29, 1902 (1861).

Leucobryum crispum C. Müll.

Cargadira, Apolo region, 2400 meters, July 29, 1902 (1869).

Leucobryum Martianum (Hornsch.) Hampe.

Lower Sorata river, 900 meters, June 13, 1902 (1866); Tumupasa, 540 meters (1867); Mapiri, 480 meters (1870).

LEUCOBRYUM GIGANTEUM C. Müll.

Near Atten, 1800 meters, August 6, 1902 (1864); common near the lower Sorata river at 1200–1500 meters.

OCTOBLEPHARUM ALBIDUM (L.) Hedw.

Mapiri, 480 meters, September 17, 1901 (1863); Tumupasa, 540 meters, December 8.

OCTOBLEPHARUM PULVINATUM Mitt.

On stumps, Tumupasa, 540 meters, January 3, 1902 (1862).

FISSIDENS CRISPUS Mont.

Sorata, 2250 meters, on clay bank, June 3, 1902 (1697). Determined from description only.

FISSIDENS KEGELIANUS C. Müll.

San Juan, Apolo-Lanca trail, 1050 meters, March 22, 1902 (1694). These specimens seem to be nearer to Trinidad specimens than to Spruce's from the Rio Negro, in having rather narrow leaves and short stems.

Fissidens (*Heterocaulon*) **excurrentinervis** sp. nov.

Dioicous; male plants 0.25 mm. high, 3- or 4-leaved at the radiculose base of the much larger sterile and fertile stems. Sterile stems 2 mm. high, with 8 to 10 pairs of leaves, the lower minute, the middle broadly oblong-lanceolate, about 0.5 mm. long and one third as broad, the upper often slightly smaller and closely imbricated, all smooth, without border, nearly entire, acutely pointed, with costa vanishing 2 or 3 cells below apex, the sheathing lamina extending four fifths or more up, dorsal lamina gradually narrowing below and disappearing three fourths down or before; leaf-cells rather irregularly hexagonal, 8–12 μ long. Fertile stems scarcely 1 mm. high, with 3 or 4 pairs of leaves, the perichaetial much narrowed above, often reduced to the stout excurrent costa only, with the clasping part more or less truncate at apex: seta erect, up to 4 mm. long; capsule ovate-oblong, erect, 0.8 mm. long, not constricted under the mouth when dry, with a short, obliquely beaked lid, its height equalling itsbasal diameter; annulus none; teeth of peristome attached well below mouth, rather irregular, erect, red, smooth, split about one half down; exothecal cells thin-walled, short oblong, 2 or 3 rows about mouth transversely elongated: spores smooth, up to 13 μ in diameter.

Juliaca, 3820 meters, May 14, 1902, on dry ground (2859).

FISSIDENS HORNSCHUCHII Mont.

Apolo, 1440 meters, July 10, 1902 (1699); Tumupasa, 540 meters, January (1695).

Fissidens (*Aloma*) macroblastus sp. nov.

Evidently dioicous. Fertile plants about 2 mm. high, 6- or 7-leaved; the upper leaves 1 mm. long, oblong-lanceolate, acute, entire or somewhat crenulate, smooth and without border, nerve vanishing 4 or 5 cells below apex, sheathing lamina extending scarcely one half up, dorsal lamina broad above, gradually narrowing to stem; leaf-cells often somewhat obliquely elongated-hexagonal, the larger up to 20 × 30–40 μ: seta up to 7 mm. high; capsule oblong, 0.5 mm. long, with erectly rostrate lid about as long; calyptra narrowly mitrate, not split, covering beak only; teeth of peristome abruptly bent outward at base, then incurved, on falling of lid, split scarcely one half down, the forks very unequal and filiform; exothecal cells mostly nearly square, 16 μ wide, with walls sinuous from the abrupt thickenings, especially in angles, cells just under the mouth smaller, but not transversely elongated, those of the lid with interior area much less than that occupied by the greatly thickened walls; annulus none: spores up to 10 μ.

Tumupasa, 540 meters, on earth of upturned stump, January 8, 1902 (1696).

FISSIDENS ASPLENIOIDES (Sw.) Hedw.

Pelichuco river, 2400 meters. On earth and rock near water-mark along stream, April 30, 1902 (2772, 2771).

Moenckemeyera obtusifolia sp. nov.

Stems simple and appearing dioicous or with a fruiting branch just under the male flower and thus autoicous, up to 8 mm. high with about 13 pairs of leaves imbricated above: lower leaves very small and somewhat acutely pointed, above up to 1 mm. long, oblong-linear or slightly lanceolate with mostly obtuse apex; clasping part of leaf extending a little above the middle with its apex at or near costa; dorsal lamina as wide above as ventral, usually gradually narrowing to base of costa; leaf-cells uniform, 6–8 μ in diameter, mammillose, forming a crenulate margin all round, or sometimes the clasping part with cells in margin elongated, forming a

slight, entire border; costa vanishing 2 or 3 cells below apex: seta 2–3 mm. high; capsule 0.5–0.75 mm. long, oblong, with obliquely beaked lid 0.25 mm. long; exothecal cells mostly short oblong, up to 24 μ wide, with somewhat thickened, scarcely sinuous walls, the 3 or 4 rows about mouth one third as large and rather irregular but not transversely elongated; teeth of peristome erect, pale, more or less hyaline, undivided, distinctly cross-barred below and more or less vertically striate throughout, somewhat papillose; calyptra small, mitrate, split one half up: spores nearly smooth, up to 16 μ in diameter.

Tumupasa, 540 meters, at base of trees, January 20, 1902 (1700); also on fallen logs (1703); Apolo, on fallen logs, July 7, 1902 (1698).

SYRRHOPODON ELATIOR Hampe.

Near Apolo, 1650 meters, on sandy bank along stream, July 25, 1902 (1858).

SYRRHOPODON GOYAZENSIS Broth.

Near Atten, 1650 meters, on earth of shaded hillside, August 16, 1902 (1859).

SYRRHOPODON GAUDICHAUDII Mont.

Near Atten, 1800 meters, on tree trunks, August 6, 1902 (1856).

SYRRHOPODON LEPRIEURI Mont.

Near Achiquiri, 600 meters, on earth, June 17, 1902 (1857).

Syrrhopodon tricolor sp. nov.

In deep mats with flexuous-erect stems up to 11 cm. high, bearing few branches and dense tufts of radicles on the older parts: stem-leaves up to 3.5 mm. long, lanceolate from an obovate hyaline clasping base, gradually narrowed to the acute, irregularly serrate apex; upper leaf without border, finely papillose on both sides, when dry more or less twisted and incurved, when moist reflexed, of rather obscure, hexagonal cells 6–8 μ in diameter; leaf-margin below entire and narrowly reflexed to the basal part; hyaline cells of base from elongated-hexagonal to rectangular, up to about 60 μ long and 12–15 μ wide, extending upward from one third to nearly one half the length of the leaf, with the green cells running down a short distance next costa and margin on either side; the more or less yellow border of basal part

5 or 6 cells wide and papillose; costa vanishing a little below the apex, papillose on back; perichaetial leaves very similar to stem-leaves but with longer, loosely clasping base: seta up to 12 mm. high; capsule 2.5 mm. long, narrowly ovate-cylindrical, slightly curved, with conical lid 0.7 mm. long; annulus none; exothecal cells irregularly elongated-hexagonal, thin-walled, the 6 or 8 rows about mouth much smaller and dark red; stomata about base of capsule, oblong, 35 μ long; calyptra smooth, split one third up, 4 mm. long, extending one half down capsule; peristome-teeth golden-brown, irregularly divided, of unequal length, not papillose: spores rough, up to 18 μ in diameter.

Pelichuco, 3600 meters, on ground among bushes on mountain side, May 4, 1902 (2846).

SYRRHOPODON MIQUELIANUS C. Müll.

Lower Sorata river, 900 meters, on trees, June, 1902 (1920). Specimens without fruit but with abundant gemmae at the apex of pedicel-like leaves.

SYRRHOPODON CIRCINATUS (Brid.) Besch.

Near Mapiri, 510 meters, September 23, 1901 (1921). On decayed log, not fruiting but with gemmae like the preceding. Determined from description only.

SYRRHOPODON BRACHYSTELIOIDES C. Müll.

Near Atten, 1650 meters, on palm trunk, August 9, 1902 (1860). Specimens up to 4 or 5 cm. high and without peristome.

SYRRHOPODON LYCOPODIOIDES (Sw.) C. Müll.

Santa Anna, 1800 meters, Apolo region, July 29, 1902 (1770). On trees in dark heavy forest. These specimens have the leaves rather broad, pale-margined and more or less covered with radicles. I should refer them to *S. rhizogonioides* C. Müll. (Hedwigia, 39: 266. 1900), but the leaves are papillose and the other characters seem to run into the darker colored form.

Calymperes Bolivianum sp. nov.

In compact mats with erect, simple or branching, sparsely radiculose stems, up to 2.5 cm. high: leaves when dry crispate with incurved margins, when moist erect-spreading from

the clasping base; stem-leaves about 3.5 mm. long, the obovate sheathing base 1.5 mm. long with a nearly linear limb obtusely pointed; perichaetial leaves very similar to stem-leaves but with somewhat larger loosely clasping base and up to 5 mm. long; leaf-margins serrulate to or near base with a thickened, terete border in upper part; costa just above base 80 μ wide, vanishing several cells below apex of leaf and often bearing on its upper side near termination a small cluster of oval to nearly cylindrical propagulae; leaf-cells above mammillose, about 6 μ in diameter, the band of elongated, narrow cells (teniola) near margin of lower leaf not extending into upper limb; hyaline cells more or less rectangular, from nearly square to twice longer than broad, often 30 μ wide toward costa and occupying most of lower limb, with green cells extending downward a short distance on either side of costa and at margins: seta about 4 mm. long; capsule oblong, 2 mm. long, with conical-rostrate lid 0.75 mm. long; calyptra persistent, plicate, scabrous above: spores nearly smooth, up to 20 μ in diameter.

Mapiri, 480 meters, on tree trunks, September 24, 1902 (1804).

Weisia tortivelata sp. nov.

Apparently dioicous. In cespitose, rather light green tufts with stems up to 8 mm. high: leaves up to 5 mm. long, crispate when dry, erect-spreading when moist, the perichaetial from a pale somewhat enlarged base, long linear-lanceolate with flat margins, acute apex and costa very short-excurrent, those of stem similar but shorter with scarcely enlarged base; leaf-cells small, obscure, papillose above, rectangular, nearly hyaline below: seta pale yellow, up to 2 cm. high; capsule nearly straight, cylindrical, not furrowed when dry, up to 2 mm. long, with rostrate lid about one half as long; annulus large; peristome pale, short, irregular; calyptra cucullate, twisting.

Ipurima, 1200 meters, February 8, 1902 (1711).

Weisia longidentata sp. nov.

Synoicous or monoicous. In cespitose rather light green patches with stems about 2 mm. high: leaves crispate when dry, up to about 2.5 mm. long, from a somewhat larger, nearly hyaline base, almost linear above, with incurved margins, acute apex and very shortly excurrent costa; leaf-cells above small, obscure, papillose, below rectangular, up

to about 8μ wide and 30μ long: seta pale, up to 12 mm. high; capsule oval, 1 mm. long, distinctly furrowed when dry, with an obliquely rostrate lid three fourths as long; exothecal cells about mouth small, often slightly transversely elongated, in 3 or 4 rows, lower becoming much larger and rather irregular, up to 35μ wide and $40–60\mu$ long; peristome of regular, solid, papillose, red teeth, narrowly lanceolate-acuminate, extending 0.2 mm. above the mouth; annulus none; calyptra cucullate, split one half up: spores slightly roughened, up to 16μ in diameter.

Consata, 1200 meters, June 13, 1902 (2883).

This species is near *W. viridula*, but that has a less regular peristome only one half as high, a narrow annulus and leaves rather broader with leaf-cells more obscure in upper leaf.

WEISIA VIRIDULA (L.) Hedw.

Apolo, 1440 meters, July 10, 1902 (1851).

Gyroweisia Boliviana sp. nov.

Dioicous; male plants branching, with often 4 or 5 antheridial buds. In green to dark brown mats, with stems 5 or 6, rarely 10 mm. high: lower leaves small, ovate-lanceolate, acutish, upper larger, entire, mostly obtuse, up to 1.5 mm. long, mammillose on both sides but most distinctly along and near costa on back toward apex; leaf-cells distinct above, rounded or oblong, up to about 8μ wide and 12μ long, with somewhat thickened walls, all brownish, becoming paler but not hyaline below, with cells more or less rectangular, up to 10μ wide and 30μ long toward costa; costa vanishing below apex: seta up to 13 mm. high; capsule erect, oblong, 1 mm. long, with conical, obliquely beaked lid two thirds as long or more; annulus scarcely distinct or of a single row of cells breaking away irregularly; peristome-teeth pale, papillose, very irregular, scarcely extending above the mouth or longer and sometimes divided above, or the rounded articulations broader than below; calyptra almost cylindrical, slightly split up on one side: spores smoothish, up to 12μ in diameter.

La Paz, on clayey soil, 3450 meters, May 26, 1902 (1785); Sorata, 2250 meters, September 2, 1901 (1786); Yura, 2550 meters, on rock, August 11, 1901 (2868). These specimens are in habit much like *G. Lindigii* but have

leaves only two thirds as long and wider above, with larger leaf-cells and thicker cell-walls.

Trichostomum Chilense Mont.

Santa Cruz, 1500 meters, August 24, 1902 (1791); Pelichuco river, April 28, 1902, 2100 meters (2870); Sorata, 2250 meters, June 6, 1902 (1790).

Tortella caespitosa (Schwaegr.) Limpr.

Asila, near Apolo, 1140 meters, April 8, 1902 (1797). *Barbula Germainii* C. Müll., from Bolivia, seems to belong here, the specimens being simply rather undersized.

Leptodontium sulphureum (C. Müll.) Mitt.

Paradiso, San José-Apolo trail, 1200 meters, February 12, 1902 (2129).

Leptodontium luteum (Tayl.) Mitt.

Pelichuco river, 2300 meters, April 28, 1902 (2848).

Leptodontium gracilescens (C. Müll.) Par.

High hills back of Mollendo, Peru, August 5, 1901 (2884). In these specimens the cells of lower leaf differ somewhat from the Bolivian specimens and possibly should not be referred here.

Leptodontium grimmioides (C. Müll.) Par.

Ingenio, 3000 meters, September 10, 1901 (1801). These specimens are taller, with leaves more erect and less yellowish above than in Sorata specimens. The costa is smooth on the back also, and the leaf-cells less obscure above and more yellow at base. My specimens are dioicous, up to 7 cm. high, with seta 1 cm. high, a slightly curved, cylindrical capsule about 2 mm. long, the lid one third as long and teeth of peristome irregular, often split one half down or more.

Hyophila Peruviana sp. nov.

Monoicous, antheridia clustered at one side of perichaetium or a little below, enclosed in two broadly ovate leaves. Plants in dense, greenish brown cushions with stems about 2 cm. high: stem-leaves crispate when dry, erect-spreading when moist, ovate-lanceolate, acute, keeled above, flat or slightly reflexed on margin, smooth, entire, up to 2.25 mm. long, the

perichaetial up to 3 mm. long with larger, loosely clasping base and shorter point; costa vanishing just below apex; leaf-cells round to oblong above, mostly slightly transversely elongated in margins, up to about 8 μ wide and 12 μ long, the lower cells square or short-rectangular toward margin and more elongated rectangular near costa, paler than above, not hyaline: seta about 5 mm. high; capsule oblong, 1.5 mm. long, with an obliquely rostrate lid one half as long; exothecal cells thin-walled, irregular, mostly 2 or 3 times longer than broad, with stomata in one row near base; peristome none; annulus large, fragile; calyptra cucullate, extending well below the middle of capsule: spores rough, up to 18 μ in diameter.

Juliaca, Peru, 3820 meters on sandstone, May 15, 1902 (2874).

Didymodon Pelichucensis sp. nov.

Evidently dioicous. Stems up to 5 mm. high, mostly simple, with radicles at base: lower leaves oblong, mostly obtuse, much smaller than upper; leaves above about 3 mm. long, nearly linear, the perichaetial with a somewhat enlarged loosely clasping base, keeled above with flat margins, below more or less recurved on one or both sides; apex of upper leaves usually obtuse, shortly apiculate, slightly and irregularly dentate on either side, with costa vanishing several cells below point; leaf-cells above papillose, more or less hexagonal, about 6 μ in diameter, below rectangular and reddish to base: seta up to 12 mm. high; capsule oblong, erect, without annulus, the lid conical, its height 1½ times its basal diameter; teeth of peristome erect, red, papillose, divided to base into two terete segments; calyptra very long-beaked, cucullate, extending but little below the lid, up to 1.5 mm. long: spores up to 14 μ in diameter.

Pelichuco, 3450 meters, May 3, 1902 (2864). In habit this species is not unlike some of the smaller forms of *D. rubellus*.

Didymodon subtophaceus sp. nov.

Dioicous. In dusky-green, easily separating tufts with branching stems, up to 2 cm. high, with few radicles near base: stem-leaves incurved when dry, erect-spreading when moist, the upper about 2 mm. long, lanceolate, finely papillose, with more or less obtuse and cucullate apex and margins

somewhat recurved and of a double thickness of cells; perichaetial leaves not sheathing, similar to those of stem; leaf-cells pale, thin, hexagonal, 8 μ in diameter, to oblong, 12 μ long in upper part, becoming rectangular and hyaline at base; costa vanishing in apex, 60 μ wide at base, without stereid bands, the cell-walls being uniformly thickened throughout leaf in cross-section: seta up to 1 cm. in height; capsule oblong, about 1.5 mm. long, with obliquely rostrate lid one half to two thirds as long; exothecal cells thin-walled, mostly rectangular and 2–3 times longer than broad; stomata in about 2 rows at base of capsule; teeth of peristome slender, from a very short basilar membrane, erect or nearly so, papillose, divided almost to base, or more or less cribrose below with segments sometimes united above; annulus narrow, persistent; calyptra cucullate, extending one half down capsule: spores smooth, up to 16 μ in diameter.

La Paz, 3600 meters, on wet hillside, August 18, 1901 (2869); Battallias river, 3900 meters, along ditches, August 27, 1901 (1712). In habit this species is much like *D. tophaceus*, which agrees in having no stereid bands in costa, but differs in its leaf-margin not being thickened.

Didymodon decolorans (Hampe).

Barbula decolorans Hampe, Ann. Sci. Nat. V. 3 : 348.

Sorata, 2250 meters, on earth, June 3, 1902 (1789); Pelichuco, 3300 meters, May 3, 1902 (2843). The peristome of this species consists of 16 teeth, not quite erect and more or less united along the median line. Cross-sections of leaf show about 5 guide-cells, 2 rows of thin-walled cells above and a well-defined stereid band below, also swollen border of a double thickness of cells.

DIDYMODON AMBLYSTEGIUS (C. Müll.) Broth.

Sorata, 2250 meters, on rock, October 3, 1902 (1722). These specimens are up to 2.5 cm. high, and the exothecal cells are inflated or mammillose, especially on the incurved side of capsule. Specimens of Herb. Lindig, no. 2146, New Granada, resemble these Bolivian plants in every way. *Trichostomum campylopyxis* C. Müll., from Bolivia, evidently belongs here, as it is stated to differ chiefly in having the exothecal cells mammillose.

CHRYSOBLASTELLA gen. nov.

Plants in compact tufts of medium size with branching stems having well-defined central strand. Leaf-lamina above of two layers of crowded cells, highly mammillose on both upper and under surface: costa with 10 or 12 guide-cells and large stereid bands above and below. Peristome-teeth 16, erect, from a short basilar membrane, grooved or more or less divided along median line to a little above the base, often somewhat irregular. Older leaves in lower part golden orange-colored.

This genus of Pottiaceae (Trichostomeae) is related to both *Timmiella* and *Dialytrichia*. From the latter it may be distinguished by the mammillose, not papillose leaf-surface, and the double layer of cells across leaf, while *Timmiella* has 32 teeth in the peristome and under surface of leaf smooth.

Chrysoblastella Boliviana sp. nov.

Dioicous. Branching stems yellowish-green above with radicles below, up to 2.5 cm. high: leaves incurved when dry, erect-spreading when moist, lanceolate from a broadly ovate base, somewhat keeled above, with margins flat: perichaetial similar to stem-leaves but with longer, loosely clasping base; costa stout, percurrent, about 80 μ wide at base; leaf-cells above crowded, highly mammillate, obscure, 4–6 μ in diameter, below golden-colored, rectangular, 8–10 μ wide by 30–60 μ long near costa and gradually much shorter and narrower toward margin: seta about 1.5 cm. high; capsule erect, oblong-cylindrical, 2 mm. long with conical, obliquely rostrate lid one half as long; exothecal cells thin-walled, about 12 μ wide and 2–4 times longer, at mouth becoming short and small but scarcely transversely elongated; annulus of 1 or 2 rows of cells breaking away from lid in fragments; stomata 25 μ long, scattered over the short collum; peristome of 16 erect, reddish-brown teeth, more or less divided, papillose, with few distinct articulations above, from a short basilar membrane of irregular cells attached close to the mouth; calyptra smooth, mitrate, finally splitting to above the middle: spores smooth, up to 16 μ in diameter.

Pelichuco, 3450 meters, on earth, May 3, 1902 (2862).

BARBULA AMBLYACRA C. Müll.

San Juan, Apolo-Lanca trail, 1050 meters, on rock along stream, March 21, 1901 (1792); near San José, 600 meters (1787); Tumupasa, 540 meters, January, 1902 (1710).

Barbula laevigata (Mitt.) Jaeg.

Sorata, 2250 meters, on rock walls, June 6, 1902 (1798).

Barbula fusca C. Müll.

Pelichuco, 3450 meters, May 5, 1902 (2844); near Ingenio, 3000 meters, September 10, 1901 (1800).

Barbula apiculata Hampe.

Sorata, 2250 meters, on walls of earth and rock, August 30, 1901 (1799).

Streptopogon erythrodontus (Tayl.) Wils.

Tacacoma, 3000 meters, on trees, June 10, 1902 (1842); above Sorata, September 27, 1901, 3000 meters.

Streptopogon setiferus Mitt.

Pelichuco river, 2400 meters, on trees, April 29, 1902 (2854).

TERETIDENS gen. nov.

Plants small, in loosely cespitose, pale green patches. Slender stems with distinct central strand. Leaves laxly spreading, nearly linear or lanceolate-linear with broad, rounded apex: costa not percurrent, in cross-section showing a distinct stereid band with a single row of large cells above and below: leaf-cells elongated-hexagonal, smooth, with walls often collapsing. Capsule oblong, with distinct collum about one third its length: peristome-teeth 32, erect, uniform, from very short basilar membrane: calyptra mitrate, more or less split upward around the base.

This genus of Pottiaceae (Pottieae) is evidently near *Splachnobryum*, but differs in having 32 distinct teeth, a well-defined collum, large annulus, rostrate lid and mitrate calyptra.

Teretidens flaccidus sp. nov.

Autoicous; male flower at apex of branch with perigonial leaves similar to the perichaetial, but shorter. Stems more or less erect, branching, about 0.5 cm. high and 0.12 mm. in diameter: leaves but little wider toward base, up to 2.5 mm. long and 0.5 mm. wide, with rounded, serrulate apex; leaf-margin flat, not bordered, serrulate about one third down; leaf-cells above very lax, hyaline, elongated rhomboidal to hexagonal, below longer, 20 μ wide by 150 μ long or more; costa about 30 μ wide at base and vanishing 3 or 4 cells or more below

apex: seta 5–6 mm. high; sporangium oblong, when dry and empty much contracted under mouth, 0.75–1 mm. long, gradually narrowed to a stomatose collum one third its length or more: exothecal cells elongated rhomboidal to hexagonal, 16–25 μ wide and up to 40 μ long; lid conical, slightly obliquely rostrate, nearly 1 mm. high; annulus broad and distinct; teeth of peristome from a very short membrane attached close to mouth, terete, red, densely and somewhat spirally papillate-striate, indistinctly articulate; calyptra smooth, mitrate, split below and descending one half down capsule: spores slightly rough, up to 18 μ in diameter.

Lower Cocos river, 900 meters, on clay bank, March 24, 1902 (1707).

TORTULA MNIIFOLIA (Sull.) Mitt.

San Juan, Apolo-Lanca trail, 1050 meters, March 22, 1902 (1793).

TORTULA PICHINCHENSIS Tayl.

Juliaca, Peru, 3780 meters, on sandstone, May 16, 1902 (2842).

TORTULA GLACIALIS (Kunze) Mitt.

Sorata, 2250 meters, on rock, June 3, 1902 (1802); Pelichuco river, 2400 meters, April 29, 1902 (2849).

TORTULA ANDICOLA Mont.

Pelichuco, 3450 meters, May 5, 1902 (2845). The leaf-apex is variable, either entire or with a few teeth just below the base of the sharply dentate excurrent nerve.

ALIGRIMMIA gen. nov.

In compact loosely cohering cushions on rock. Stems with large central strand, fasciculately branching, about 1 cm. high. Lower leaves very small, upper broadly ovate-lanceolate, smooth, obtusely pointed, with entire margins incurved above, in cross-section showing a distinct stereid band in the broad costa with one row of cells below and two rows of somewhat larger cells above, bearing on their ventral surface 8 or 10 well-developed lamellae. Seta erect: capsule oblong, smooth, with erectly rostrate lid and large annulus; peristome-teeth lanceolate, erect, papillose, solid or somewhat split along median line: calyptra mitrate, smooth above, plicate in lower half and lobate at base.

This genus of Grimmieae is near *Indusiella* Broth. & C. Müll., found in very similar situations in Turkestan, but *Indusiella* differs in having no central strand, no lamellae on the costa and the teeth of peristome more or less divided into 3 segments.

Aligrimmia Peruviana sp. nov.

Autoicous; male flower terminal, the 6 or 7 antheridia with few paraphyses enclosed in about 4 short, broadly ovate, obtuse leaves with scarcely distinct costa not lamellose. Tufts dull green: stems about 225 μ in diameter, central strand 80 μ in diameter: leaves closely imbricated, erect when dry, spreading when moist, ovate-lanceolate, 1–1.5 mm. long, smooth, entire, incurved above, obtusely pointed; costa extending to near apex, about 20 μ wide at base with 8 or 10 lamellae up to 6 cells high on ventral surface; leaf-cells below square to short rectangular, 12–16 μ wide, above smaller and roundish: seta up to 2 mm. high, with erect, oblong, smooth capsule scarcely 1 mm. long, bearing a conical, erectly rostrate lid nearly as long; annulus large, well developed; teeth of peristome lanceolate, erect, reddish-brown, papillose, entire or more or less divided along the median line with articulations indistinct; calyptra mitrate, smooth above, plicate one half up, lobate at base: spores smooth, up to 12 μ in diameter.

Arequipa, 2250 meters, on dry rock, August 8, 1901 (2820).

Grimmia Andina Mitt.

Juliaca, Peru, 3780 meters, on sandstone, May 16, 1902 (2817).

Grimmia (Tricostatae subgen. nov.) trinervis sp. nov.

Dioicous. Plants in compact, grayish-green, loosely cohering cushions: stems fasciculately branching, up to 1 cm. high: leaves closely imbricated, erect when dry, spreading when moist, all smooth, entire, with smooth hair-point, the lower oblong-lanceolate, 0.75–1 mm. long with hair-point about one half as long, the upper and perichaetial broadly ovate-lanceolate, up to 1.5 mm. long, with hair-point sometimes nearly equalling blade in length; stem-leaves all more or less deeply triplicate above and tricostate often to base; perichaetial leaves mostly faintly unicostate to base and scarcely or not plicate above; cross-sections of stem-leaf show 2 guide-cells in primary costa with 1 or sometimes 2

rows of thin-walled cells on dorsal side, and the secondary costae very similar but smaller than the primary; the leaf lamina above is mostly of two layers of cells but broken here and there by longitudinal rows of one thickness; leaf-cells below short rectangular, up to about 10 μ wide and 30 μ long, with thin walls, above becoming smaller and roundish to transversely elongated: capsule immersed, ovate-globose, smooth, 1 mm. long on a doubly bent seta nearly as long; peristome and annulus wanting; lid acute, its height less than basal diameter; calyptra lobate-mitrate: spores smooth, up to 10 μ in diameter.

Juliaca, Peru, 3780 meters, on dry sandstone, May 15, 1902 (2814).

Grimmia micro-ovata C. Müll.

Juliaca, Peru, 3780 meters, on dry sandstone, May 15, 1902 (2813).

Grimmia longirostris Hook.

La Paz, 3600 meters, August 23, 1901 (2818); Huallata Pass, 4200 meters, August 29, 1901 (1779); Pelichuco, 3600 meters, May 4, 1902 (2815); Tacacoma, 3300 meters, June 10, 1902 (1778).

Grimmia fusco-lutea Hook.

Huallata Pass, 4200 meters, August 29, 1901 (1781); above Tolapampa, 4200 meters, September 10, 1901 (1782). These specimens are not the same as those called *G. fusco-lutea*, collected by Liebmann in Orizaba, Mexico. They are, however, very near the figure in Hook. Musc. Exot. *pl. 63*, and agree well with Mitten's description.

Grimmia (*Eugrimmia*) pansa sp. nov.

Dioicous; male plants slender, scarcely branching, with few flowers: perigonial leaves broadly ovate, acute, little more than 1 mm. long: antheridia 0.7 mm. long, without paraphyses. Growing in large mats, greenish brown above, blackish within, with few irregular branches: stems up to 10 cm. high, in cross-section slightly oval, 160 × 180 μ, without central strand and with about 3 rows of thickened cells in walls: leaves more or less erect and incurved when dry, ovate-lanceolate, smooth, scarcely 3 mm. long and 0.6 mm. wide, with smooth hair-point in lower leaves scarcely 0.1 mm. long,

in upper about 0.5 mm. long and border mostly revolute on one side; cross-sections of upper leaf show 2 large cells on ventral side of costa and 2 rows of smaller cells on dorsal side, without stereid band, and the leaf-lamina of a single layer of cells with border not thickened or sometimes of a double row of small cells; leaf-cells with thickened, sinuous walls nearly to apex, upper cells all short, mostly roundish to transversely elongated, in middle leaf up to twice longer than broad, and toward base up to 45 μ long within, but with 3 or 4 rows at margin of shorter, broader cells: seta twisting and curving, 3–4 mm. long; capsule oblong, 1.6 mm. long, smooth, with red, conical-rostrate lid about one half as long; exothecal cells thin-walled, more or less hexagonal, often somewhat elongated, with stomata below; annulus broad, 3 or 4 rows of cells high; peristome-teeth narrowly lanceolate, not regularly split above, but more or less cribrose and slightly split here and there, somewhat papillose and with distinct articulations; calyptra lobate-mitrate, scarcely more than covering lid: spores up to 12 μ in diameter.

Pelichuco, 3450 meters, May 4, 1902 (2823).

GRIMMIA TRICHOPHYLLOIDEA Schimp.

Luipichi Pass, 4500 meters, September 27, 1902 (1777).

RHACOMITRIUM CRISPIPILUM (Tayl.) Jaeg.

Ingenio, 2700 meters, September 26, 1902 (1773).

RHACOMITRIUM BRACHYPUS (C. Müll.) Par.

Pelichuco, 3450 meters, May 4, 1902 (2822).

RHACOMITRIUM DIMORPHUM (C. Müll.) Par.

Ingenio, 3000 meters, September 10, 1901 (1775); near Tacacoma, 3600 meters, June 9, 1902 (1784).

Rhacomitrium sublanuginosum Schimp. MSS.

Stems blackish, with abundant short branches: leaves ovate-lanceolate to lanceolate, the upper about 2.5 mm. long and 0.4–0.5 mm. wide, mostly revolute on one side, with a more or less sinuous, flat hair-point up to as long as blade and entire or minutely serrulate, the hyaline margin not extending downward on either side of the colored costa; lower leaves much shorter, without hyaline point, the apex blunt; leaf-cells narrow and elongated to apex, in margin at base becoming broader and shorter, often nearly square to twice longer than wide: immature capsule 2 mm. long, with rostrate lid two thirds as long; seta 4.5 mm. long.

Above Ingenio, 4200 meters, September 10, 1901 (1776); near Tacacoma, 3600 meters, June 9, 1902 (2886). These specimens are from nearly the same altitude and region in which Mandon obtained his no. 1637, on which the species is based. The description is from Mandon's specimen.

ANOECTANGIUM EUCHLORON (Schwaegr.) Mitt.

San José-Apolo trail, near Cortez, 1800 meters, February 14, 1902 (1717); below Pelichuco, 2700 meters, April 30, 1902, on rock (2866).

ANOECTANGIUM MANDONIANUM Schimp.

Sorata, 2250 meters, on rock, June 6, 1902 (1720).

AMPHIDIUM CYATHICARPUM (Mont.) Broth.

Tacacoma, 3300 meters, June 10, 1902 (1849); Pelichuco, 3600 meters, May 4, 1902 (2857).

Zygodon vestitus sp. nov.

Apparently dioicous. Plants in compact tufts 2 or 3 cm. high: stems with few radicles above, bearing great numbers of ovate to obovate and oblong propagulae, up to 80 μ long and 32 μ in diameter, with 3 to 5 transverse walls: leaves crispate when dry, squarrose-reflexed when moist, finely papillose on both sides, lanceolate, very acute, keeled, entire, with mostly flat margins; lower leaves less than 1 mm. long, upper up to 2.25 mm. long and 0.3 mm. wide; costa about 40 μ wide at base, vanishing in apex; leaf-cells somewhat roundish or slightly elongated, 5–7 μ in diameter above, becoming paler and elongated rectangular below: seta 7 mm. long; capsule elongated with sporangium about 1.7 mm. long and collum 0.7 mm. long; peristome of 8 cilia; lid slightly obliquely rostrate, nearly 1 mm. long: spores somewhat roughened, up to 20 μ in diameter.

Sorata, 2250 meters, on trees, September 3, 1901 (1875).

Zygodon fruticola sp. nov.

Apparently dioicous. In rather loose tufts up to 1.5 cm. high: stems, without radicles above, bearing numerous, finally more or less cylindrical propagulae up to 140 μ long and about 25 μ in diameter: leaves incurved-appressed, scarcely crispate when dry, recurved-spreading when moist, finely papillose, broadly lanceolate, up to about 0.5 mm. wide and 2 mm. long, very acute, entire, flat on margins;

costa vanishing in apex; leaf-cells scarcely elongated, often extending nearly to base: seta scarcely 4 mm. long; capsule narrowly oblong, with sporangium about 1.25 mm. long and collum one half as long; peristome of 8 cilia; lid and calyptra not seen: spores roughish, up to 16 μ in diameter.

Hills near Mollendo, 540 meters, on bushes, August 5, 1901 (2887).

ZYGODON PERUVIANUS Sull.

Pelichuco, 3450 meters, May 4, 1902 (2861).

ZYGODON ANDINUS Mitt.

Pelichuco, 3000 meters, April 30, 1902 (2875); Cargadira, 2400 meters, on trees, July 30, 1902 (1874); Santa Cruz, 1500 meters, on trees, August 24, 1902 (1872); near Apolo, 1650 meters, July 25, 1902 (1873). These specimens have leaves denticulate above, 8 cilia and flowers mostly autoicous, sometimes synoicous.

ZYGODON SUBDENTICULATUS Hampe.

Ingenio, 2700 meters, on bushes, September 27, 1902 (1715).

ZYGODON LINGUIFORMIS C. Müll.

Santa Cruz, 1650 meters, on trees, August 25, 1902 (1871); Pelichuco river, 2100 meters, April 29, 1902 (2865).

ORTHOTRICHUM PATULUM Mitt.

Sorata, 2700 meters, September 3, 1901 (1833). The only species with immersed stomata collected. The exothecal cells are mostly very thin-walled and short-rectangular, up to about 20 μ wide and 30–35 μ long; lid and calyptra not seen. Determined from description only.

ORTHOTRICHUM ELONGATUM Tayl.

Pelichuco, 3600 meters, on bushes, May 5, 1902 (2812), Sorata, 2700 meters, September 27, 1902 (1841); Tacacoma, 3000 meters, June 10, 1902 (1832).

ORTHOTRICHUM PARIATUM Mitt.

Above Sorata, 2700 meters, September 8, 1901 (1834).

Orthotrichum epilosum sp. nov.

Monoicous. Plants in more or less loose tufts with branching stems up to 4–5 cm. high; leaves somewhat spreading

when dry, widely spreading from a more erect base when moist, up to 5 mm. long, lanceolate, very narrowly acute, keeled, borders recurved below, flat toward apex; leaf-cells all more or less elongated in upper leaf, 8–16 μ long, with low papillae, toward base up to 40–50 μ long, with somewhat thickened walls: capsule oval-oblong, 8-ribbed, short-exserted, about 1.5 mm. long on a seta of equal length; peristome of 8 papillose teeth with paler, papillose, lanceolate segments, at base one half the width of teeth and of equal height; stomata superficial; lid convex-apiculate; calyptra without hairs, plicate, more or less undulate or mammillate on the ridges, finally split at base: spores nearly smooth, up to 25 μ in diameter.

Pelichuco, 3300 meters, May 4, 1902, on bushes (2811); Tacacoma, 3000 meters, June 10, 1902, on bushes (1835); above Sorata, 2700 meters, September 8, 1901, on trees (1836).

ORTHOTRICHUM EXSERTISETUM C. Müll.

Above Sorata, 2700 meters, September 27, 1902 (1839).

Orthotrichum Tacacomense sp. nov.

Monoicous. Somewhat compactly tufted plants with much-branched stems up to 3 cm. high: leaves rather loosely appressed or somewhat spreading when dry, spreading and more or less recurved when moist; stem-leaves 3–4 mm. long, broadly lanceolate, acute, keeled, recurved on margins below with margins flat above; perichaetial leaves with larger ovate base up to 5 mm. long, with costa more or less excurrent into a short point; leaf-cells above elongated, 8–16 μ long and 6–8 μ wide, with low papillae, below, in stem-leaves, cells up to about 40 μ long with walls somewhat thickened and pitted, in perichaetial leaves lower cells pale and longer with thinner walls: capsule oblong, at first smooth, slightly contracted under the mouth, finally distinctly 8-striate one half down, up to 2.25 mm. long, on a seta about 0.75 mm. long, the point of the convex-apiculate lid scarcely or not projecting above the tips of the perichaetial leaves; stomata superficial; peristome with a distinct but often low preperistome; teeth 8, pale, papillose, more or less split along the middle; cilia 8, very pale, papillose, narrow below, often broader above and more or less united in pairs, with rounded, loosely jointed, irregular articulations; calyptra sparsely hairy throughout, deeply plicate, erose at base: spores pale, slightly roughened, up to 24 μ in diameter.

Tacacoma, 3000 meters, June 10, 1902, on trees (1837); Sorata, 2700 meters, September 3, 1901, on trees (1838).

ORTHOTRICHUM APICULATUM Mitt.

Sorata, 2700 meters, September 3, 1901, on trees (2888).

MACROMITRIUM DIDYMODON Schwaegr.

Near Apolo, 1800 meters, on trees, July 25, 1902 (1818).

MACROMITRIUM MACROTHELE C. Müll.

Near Atten, 1650 meters, on trees, June 19, 1902 (1817).

MACROMITRIUM OBTUSUM Mitt.

Isapuri, 450 meters, on trees, October 2, 1901 (1828).

MACROMITRIUM TUMIDULUM Mitt.

Near Tumupasa, 900 meters, on wood, December 3, 1901 (1831); Santa Cruz, 1500 meters, on rock, April 24, 1902 (2755). These specimens agree with Spruce no. 101, the only collection cited, but differ from Mitten's description in having a distinctly ribbed capsule, a double peristome and pedicels about 12 mm. long.

MACROMITRIUM SWAINSONI (Hook.) Brid.

New Brazil, 1500 meters, June 14, 1902 (1819). These specimens are near those called *M. Swainsoni* from Herb. Gardner, Brazil, 1840. The upper leaf-cells are small and round, the lower elongated, in the margin at base one row becoming hyaline and more or less highly papillate-toothed; peristome low, apparently simple.

MACROMITRIUM STELLULATUM (Hornsch.) Brid.

Tumupasa, 540 meters, on trees, December 16, 1901 (1830). There is a double peristome in these specimens, the inner of lanceolate segments nearly as high as the outer; leaves below without border. Evidently not the species figured as *M. stellulatum* in Engler & Prantl, which has a distinct, broad border below and is much like J. Weir no. 141, cited by Mitten under *M. Swainsoni*, but apparently neither that nor *M. stellulatum*.

Macromitrium subdiscretum sp. nov.

Pseudautoicous. In compact tufts up to 3 cm. high: stems creeping, with branches densely radiculose below and branch-

lets up to 1 cm. long above: leaves more or less spirally twisted on branches when dry, erect-spreading when moist, more or less linear-lanceolate, 2–3 mm. long, with broadly acute point, mostly serrulate in upper one third, the margins flat above, recurved below on one side; perichaetial very similar to stem-leaves but a little shorter; leaf-cells all elongated with more or less thickened walls, above mammillose, about $8 \times 12–16 \mu$, in middle leaf arranged in distinct rows, at base highly papillose, paler and longer, a single row in margin hyaline and elongated with thin straight walls; costa not quite percurrent: seta smooth, up to 1 cm. high; capsule short-ovate, 1.5 mm. high, ribbed below the mouth, with a convex-conical, long-beaked lid nearly as high; peristome double, the outer of teeth united below, blunt or irregular at apex and revolute when dry, the inner a membrane more or less lacerate above into narrow segments reaching almost as high as teeth; preperistome more or less evident, a few pale cells extending here and there above the rim of capsule; calyptra without hairs, somewhat rough at apex, deeply incised below: spores minutely roughened, up to 32μ in diameter.

Santa Anna, Apolo region, 1950 meters, July 28, 1902 (1820).

MACROMITRIUM ULOPHYLLUM Mitt.

Santa Anna, 1950 meters, Apolo region, July 28, 1902 (1826). Determined from the rather incomplete description only. The pedicels are about 12 mm. high: peristome double, the outer of teeth mostly united, with articulations convexly thickened on outer face and finely papillate, the inner a pale, papillose membrane about as high as the outer and irregularly lobed or cleft above: preperistome with cells projecting here and there above the rim of capsule.

Macromitrium atroviride sp. nov.

Apparently dioicous; male flowers not found. In dark green, rather loose tufts with creeping stems bearing rather distant, erect, simple or divided, slightly radiculose branches up to 2.5 cm. high: stem-leaves crispate when dry, somewhat incurved-spreading when moist, nearly linear from a little wider base, up to about 0.4 mm. wide and 4 mm. long, at apex acute and irregularly serrate, the margins flat above, recurved on one side below; inner perichaetial leaves short,

entire, from a wider base gradually narrowing to acute apex; leaf-cells above roundish, mostly 4–6 μ in diameter, mammillate, toward base elongated with somewhat thickened walls, from nearly smooth to highly papillose with a few hyaline, smooth cells at one side of costa and a row of pale more or less mammillate-inflated cells in margin; costa vanishing in apex: seta smooth, more or less curved, about 9 mm. long; capsule ovate, 2 mm. long, smooth or indistinctly striate with rostrate lid about 1.2 mm. long; peristome double, the outer of pale, lanceolate, obtuse teeth, divided to near base, with articulations not convex on outer face and somewhat striate in various directions, the inner, a low, pale, scarcely evident membrane; preperistome double, of large thin cells projecting irregularly above the rim of capsule; calyptra without hairs, papillose at apex, deeply lacerate below: spores slightly roughened, up to 28 μ in diameter.

Apolo, 1500 meters, on tree trunks, April 17, 1902 (1822).

MACROMITRIUM PENTASTICHUM C. Müll.

New Brazil, 1500 meters, near lower Sorata river, on wood, June 15, 1902 (1821). I have seen no specimens for comparison.

MACROMITRIUM SUBSCABRUM Mitt.

Near Paradiso, 1500 meters, San José-Apolo trail, February 12, 1902 (1824); Cargadira, 2400 meters, July 29, 1902 (1825). Determined from description only.

MACROMITRIUM TOCAREMAE Hampe.

Below Pelichuco, 2700 meters, on rock, April 30, 1902 (2757). In "Engler & Prantl," Brotherus has classed this species with those having more or less furrowed capsule, but all the specimens I have seen have, essentially, a smooth capsule.

MACROMITRIUM SUBLAEVE Mitt.

Ipurima, 1200 meters, San José-Apolo trail, February 9, 1902 (1829); near Apolo, 1800 meters, February 14, 1902 (1827).

MACROMITRIUM SOLITARIUM C. Müll.

Pelichuco, 3300 meters, April 30, 1902 (2756).

SCHLOTHEIMIA TRICHOMITRIA Schwaegr.

Apolo, 1500 meters, on trees, July 10, 1902 (1812); near Atten 1800 meters, June 19, 1902 (2890).

SCHLOTHEIMIA FUSCO-VIRIDIS Hornsch.

Santa Cruz, 1500 meters, April 24, 1902 (2753); Paradiso, 1200 meters, February 12, 1902 (1807).

SCHLOTHEIMIA JAMESONI (W. Arn.) Brid.

Apolo, 1500 meters, July 7, 1902 (1806).

SCHLOTHEIMIA RUGIFOLIA (Hook.) Brid.

Apolo, 1440 meters, June 24, 1902 (1809).

SCHLOTHEIMIA SPRENGELII Hornsch.

Near Atten, 1650 meters, June 19, 1902 (1805); Pelichuco river, April 28, 1902 (2754).

SCHLOTHEIMIA ANGUSTATA Mitt.

Near Atten, 1650 meters, June 19, 1902 (2889); Mapiri, 480 meters, September 13, 1901 (1810).

PHYSCOMITRIUM TURGIDUM Mitt.

Huallata Pass, 4260 meters, August 29, 1901 (2893).

FUNARIA SUBTILIS (C. Müll.) Broth.

Pelichuco, 3600 meters, May 3, 1902 (2769).

FUNARIA ANDICOLA (Mitt.) Broth.

Huainachoirisa river, 1140 meters, July 26, 1902 (1847); Apolo, 1440 meters, March 1, 1902 (1845).

FUNARIA ACUTIFOLIA (Hampe) Broth.

Near Apolo, 1500 meters, February 14, 1902 (1713).

FUNARIA JAMESONI Taylor.

Juliaca, 3780 meters, May 14, 1902 (2770).

FUNARIA CALVESCENS Schwaegr.

Pelichuco river, 1500 meters, April 27, 1902 (2768); Sorata, 2250 meters, June 6, 1902 (1844); Achiquiri, 600 meters, June 17, 1902 (1843).

Funaria macrospora sp. nov.

Autoicous: perigonial leaves entire: plants near *F. hygrometrica* in size. Stems more or less elongated, radiculose below, with leaves clustered above: leaves ovate to obovate, up to 4 mm. long, acute, entire, concave, with costa vanishing 1 or 2 cells below apex; leaf-cells above more or less hexagonal, up to about 30 μ wide and 40–50 μ long, below rectangular and up to 40 μ wide and 150 μ or more

long: seta 1.5 cm. high, straight when dry, pendent when moist; capsule about 3 mm. long, curved, furrowed when dry with oblique mouth 0.5 mm. in diameter; annulus large; lid convex, with elongated cells in oblique rows; peristome double, teeth united at apex to small disc of hyaline cells, segments one third height of teeth, broad and blunt at apex; stomata numerous at base of collum, about 35 μ long: spores minutely roughened, up to 30 μ in diameter.

La Paz, 3450 meters, August 18, 1901 (2766).

The Dimensional Relations of the Members of Compound Leaves.*

BY CHARLES ZELENY.

The present paper is the result of an experimental study of the regulatory changes taking place in the members of the compound leaf after removal of one of the leaflets. The object of the work was to throw some light on the general question of correlation of members in the plant body. The compound leaf of the palmate type was chosen as the most convenient organ for the study because of the comparative ease with which changes may be observed and quantitatively recorded. The method of procedure may be made more clear by a statement of the standpoint from which the subject was approached.

The individual members of the compound leaf as well as of other parts of the plant respond to stimuli in a definite way. Each member is, however, limited in its reaction by its mechanical and organic relations to the other parts of the leaf. This limitation is mutual and as a result of it we get an equilibrium of forces which results in a configu-

* The experiments were performed at the New York Botanical Garden during the winter of 1901–1902, under the direction of Professor D. T. MacDougal, and I am indebted to him for many kindnesses during the progress of the work. A preliminary report of the results was given in a paper read before the Botanical Society of America, July 1, 1902.

ration more or less definite for each species. As a further consequence each member must respond not as a unit but as part of a system. If now we have a system of this kind with a definite configuration due to the mutual interaction of its members and we remove one of the component parts, we must get a disturbance of the equilibrium leading to changes in the relations of the remaining parts limited only by the extent to which the rigidity of the skeletal structures may counteract such a tendency. We may in this manner get at the forces which are active in correlation at the time of, and subsequent to, the operation. The main difficulty with the method must consist in the reaction to the stimulus of the injury itself, a factor which does not enter into the normal relations of the parts.

The special method chosen for these experiments aimed to carry along two parallel series of leaves, one with the normal relations of its members undisturbed and the other with a particular leaflet removed at the earliest possible stage. When the leaves had attained their maximum size, measurements of the length and of the angular position of the leaflets were taken. A comparison of the two series of figures gives the change produced as a result of the removal of the leaflet, because, according to the conditions of the experiment, all the other factors are alike. It is evident that the success of the method depends largely upon the care exercised in keeping the conditions of the two series the same. With this in view special precautions were taken in the choice of the leaves, in the obtaining of similar environments during the period of growth, and finally in the choice of the method of measurement.

The Method.

The method may be conveniently described under five heads:

1. The choice of leaves.
2. The operation, *i. e.*, the removal of one of the leaflets in each leaf of one series.
3. The period of growth.

4. The method of taking measurements.
5. The tabulation of data.

The Choice of Leaves.—Three species of plants were employed in the experiments: *Parthenocissus quinquefolia* (the Virginia creeper), *Trifolium pratense* (the red clover) and *Lupinus albus* (the white lupine). Each species will be taken up separately.

In the case of *Parthenocissus*, 44 normal and 67 operated leaves were used. A few vines were taken from outdoors and planted in the propagating house. They were allowed to run along a wire near the glass roof. Leaves were chosen from various portions of the stem in such a way that the distribution was as nearly as possible the same in the two series. Only leaves with five leaflets were used.

In *Trifolium*, 31 normal and 87 operated leaves were used. Several clumps of the clover were transplanted from outdoors to the propagating house and, here also, leaves were taken from various regions of the plant and the two series were made as nearly alike as possible. Only leaves with three leaflets were used.

In *Lupinus*, 16 normal and 53 operated leaves were used. The plants were raised from the seed and the order in which the leaves appeared was noted. Several plants were necessary for each series, each of which, therefore, had leaves from all the different positions. Only the first four or five leaves were used because it was desired to have the ages as nearly alike as possible and also because in many cases these were the only ones with five leaflets, those further up on the stem having six or seven.

Taking into consideration the number of cases in each group it seems improbable that there is any considerable error due to original differences between the two series of one species.

The Operation.—For the sake of clearness in description it is necessary before proceeding further to give the general topography of the leaves used. *F. 1* is a diagram of a

median section along the plane of symmetry of one of the leaves. We see that the two angles between the petiole and the leaf-surface are very unequal. The acute angle (a) is at

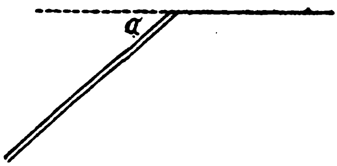


Fig. 1. Diagram to illustrate the inclination of the petiole to the leaf-surface.

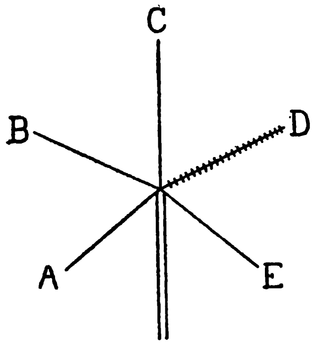


Fig. 2. Compound leaf of *Parthenocissus quinquefolia* or *Lupinus albus*. *D*, The removed leaflet in operated series.

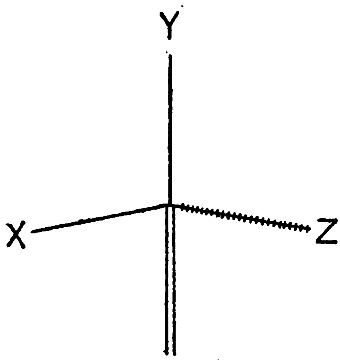


Fig. 3. Compound leaf of *Trifolium pratense*. *Z*, The removed leaflet in operated series.

the base of the leaf-system and the leaflet on the side opposite to it is the terminal leaflet. This general description holds for all three species. The value of the angle a, however, is not the same in the different cases. *F. 2* is a diagram of the leaf system of either *Parthenocissus* or *Lupinus* as seen from above. The double line represents the projection of the petiole. The terminal leaflet is lettered *C*. Starting at the left of the petiole and going in a clock-wise direction we get

successively leaflets *A*, *B*, *C*, *D* and *E*. In a similar way in *Trifolium pratense* (*f. 3*) we may call the three leaflets, *X*, *Y* and *Z*.

The removed leaflet in all cases is the one at the immediate right of the terminal one. This is leaflet *D* in *Parthenocissus* and *Lupinus* and leaflet *Z* in *Trifolium*. In *f. 2* and *3* the removed leaflet is represented by a barred line. The operation was performed as soon as the leaves started to unfold. The excision was made with a pair of dissecting scissors as near the base of the leaflet as was possible without injuring the other members. The cut surface was small, there was little or no exudation of sap and the wound healed in a short time. A slight scar remained and persisted throughout the experiment, serving as an unfailing mark for the determination of the identity of the remaining leaflets.

The Period of Growth.—After the removal of the leaflet in the operated series, both normal and operated groups were allowed to grow under conditions as nearly alike as possible. The period of growth was extended until the leaves had attained their maximum size and the experiment was closed only when there began to be danger of error on account of the drying up of some of the leaflets. The length of time varied in the different species, but in any one of them all the specimens, of both the normal and the operated series, were measured on the same day, so that the results show no error due to a difference in age. In *Parthenocissus* the length of the period of growth was thirty days, in *Trifolium* twenty-one days and in *Lupinus* forty-one days.

The conditions of light, heat and moisture were kept as nearly alike as possible in the two series. In *Parthenocissus* the position of the vines on a wire gave the different leaves very similar intensities of light. The plants of *Lupinus* and *Trifolium* were put in flower-pots kept at some distance apart in order to avoid shading.

The Method of Taking Measurements.—In each of the species, when the leaves had attained their maximum size all

were measured on the same day. The petiole of each leaf was cut off near the main stem of the plant and the leaf-systems were plotted according to the method indicated in *f.* *4* and *5*, which represent sample pages from my note-book. *F.* *4* shows ten normal leaves of *Parthenocissus* and *f.* *5* ten operated leaves of the same species. The first leaf indicated on each page was placed upon the paper and its center was held down with one finger. The petiole was indicated by a

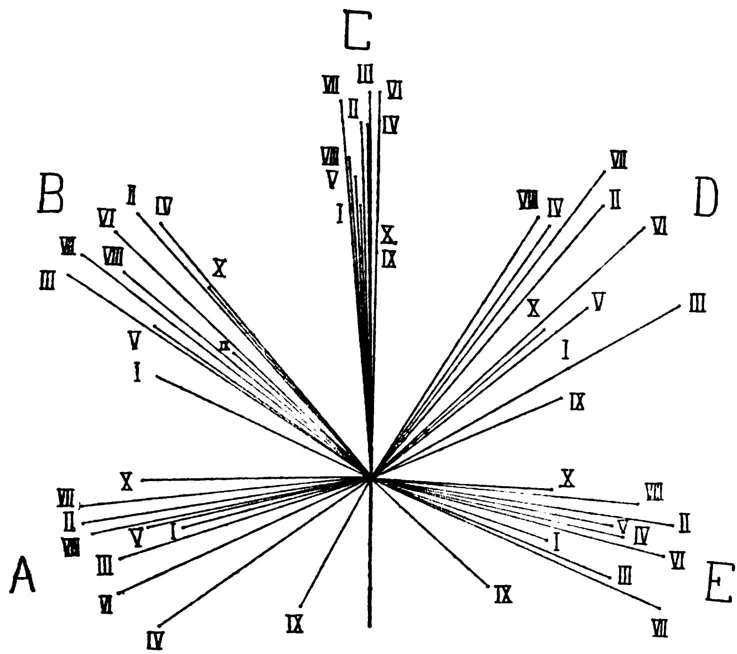


Fig. 4. (One half natural size.) ***Parthenocissus quinquefolia.*** **Ten leaves of normal series as plotted on page of note-book.**

line running from this center. The ends of the leaflets were then shown as dots, all numbered I, the different leaflets being designated by their particular letters *A*, *B*, *C*, *D* and *E* or *X*, *Y* and *Z*. The second leaf was then taken and placed so that its center and the line of its petiole corresponded with the center and petiole of the first. The ends of the leaflets were indicated by dots as before, but numbered II in this case. The remaining leaves on each page were plotted in a

similar manner. As the petiole is not in the same plane with the leaf-surface it was necessary to take great care in pressing down the leaflets so as not to distort their position or alter their length.

After all the leaves of the two series of one species had been plotted in the above manner, the measurements could be made at leisure after drawing the lines from the dots to the center. The positions are measured in degrees in a clock-

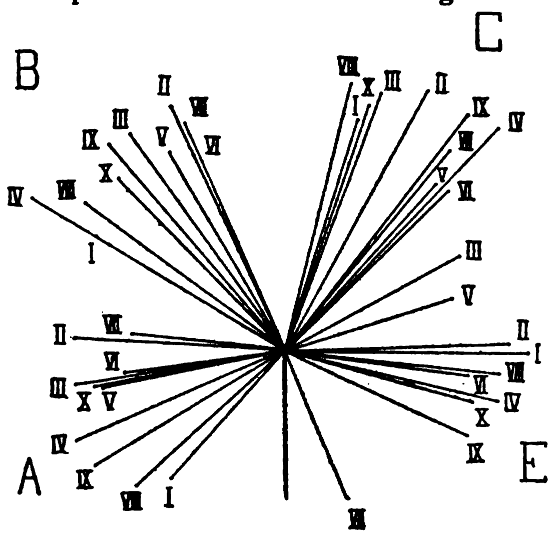


FIG. 5. (One half natural size.) *Parthenocissus quinquefolia.* Ten leaves of operated series as plotted on page of note-book.

wise (+) direction from the line representing the petiole. The lengths are in millimeters and include the distance from the tip of the leaflet to the center of the leaf. Thus we have included in the length of the leaflet, the blade and its very short petiole.

The special difficulties in each of the species may be mentioned in a few words. In *Parthenocissus* the leaves taper very gradually near the tip and have a tendency to dry up and to curve in this region. In the case of a very sharp curve at the end the prolongation of the main portion of the blade was taken instead of the curved tip as it stood. In a few cases the drying up of the tip made it necessary to approx-

imate its true end. The distance estimated was small, however. In *Trifolium* the lengths were very well defined on account of the obtuse ends of the leaflets, but great care was necessary in getting the angular positions because of the great mobility of the leaflet-petioles. In *Lupinus* no special difficulties were encountered.

The Tabulation of Data.—After the measurements are taken we have for each species two groups of figures, one of the length and position of the leaflets in the normal series and the other of the length and position in the operated series. Putting these in parallel columns we may determine the normal average length and average position of each leaflet and likewise the operated average length and average position.

As stated before, assuming that the normal averages represent the positions and lengths which the operated leaflets would have had but for the removal of one of their number, we may conclude that the difference between the operated average and the normal average in each case is a measure of the effect of the removal.

In order to indicate in some degree the trustworthiness of the results the probable error of the mean was calculated according to the well-known formula

$$\text{Probable Error of the Mean (P.E.M.)} = \frac{.6745\ C\sqrt{v_2 - v_1^2}}{\sqrt{n}}.^*$$

In cases where the choice of specimens is made at random, the validity of the results is taken for granted when the difference between the two averages is greater than the sum of their probable errors of the mean. In each of the present experiments, however, there was undoubtedly an unconscious selection as regards the length and position of the leaflets, due to the conscious attempt to make the two series similar at the start. But this factor increases the trustworthiness of the results on both sides, for the following reasons: First, any

* For the development of the formula see the text-books on the method of least squares.

selection tends to increase the probable error of the mean. Second, the selection exercised in the operated series is similar to that in the normal series of the same experiment and the difference between the averages is therefore less than it would have been if the individuals had been chosen entirely at random. We are therefore justified in concluding that the difference between the averages represents a real change when it is greater than the sum of the probable errors of the mean. Further, when we get similar results for all three species there can no longer be any doubt of the validity of the conclusions.*

The Data.

The following six tables (Tables I to VI) will in a large measure explain themselves after the foregoing discussion. There are two tables for each species, one giving the position and length of the leaflets in the normal series and the other in the operated series. The letters at the tops of the columns indicate the leaflets occupying the various positions *in the leaf*, the removed leaflet being represented by a letter enclosed in parentheses. At the bottom of the columns are the averages and below them the probable errors (P.E.M.). In Table VI the average positions as given are not necessarily the averages of the figures as they stand in the columns because some of the leaflets fluctuate between the two sides of the petiole. It is of course necessary to assume that the rotation has in each case been through the shorter arc of the circle. The figures in the first column of each table have no significance except as catalogue numbers. The dates of operation and of measurement are given below the tables.

*I wish to express my obligation to Professor C. B. Davenport for suggesting the determination of the probable errors of the averages.

TABLE I.

PARTHENOCISSUS QUINQUEFOLIA. NORMAL SERIES. POSITION AND LENGTH OF LEAFLETS.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	*D*	*E*	*A*	*B*	*C*	*D*	*E*
1	74	115	177	240	289	52.0	64.5	70.0	61.5	49.5
2	81	138	178	220	280	78.0	95.0	95.5	96.5	82.0
3	71	123	178	240	292	71.0	98.5	105.0	95.0	69.5
4	54	140	178	215	283	69.0	89.0	95.5	83.0	68.5
5	76	124	177	231	282	61.5	71.0	78.0	74.0	66.0
6	65	132	180	226	284	76.0	96.0	105.0	100.5	80.5
7	84	126	175	218	294	78.5	98.5	101.0	105.5	86.0
8	77	128	176	212	277	77.0	85.5	84.5	84.0	71.0
9	24	131	181	247	314	36.0	47.0	59.0	54.0	40.0
10	90	139	180	228	275	50.0	66.0	63.5	60.0	48.5
11	71	137	178	224	276	93.5	120.0	117.5	115.5	95.0
12	71	145	182	238	284	104.0	116.0	113.5	114.0	103.5
13	87	138	178	219	283	92.0	108.0	106.0	112.5	98.5
14	83	129	179	230	270	90.5	105.0	104.5	106.5	89.5
15	63	140	185	228	286	70.0	88.0	93.0	86.5	69.0
16	56	139	189	234	315	64.0	73.0	79.0	79.5	66.0
17	83	135	179	220	285	85.0	98.0	109.0	103.0	85.5
18	67	129	177	217	289	55.0	65.5	73.0	68.0	56.0
19	52	126	178	226	286	64.5	82.0	83.5	78.0	62.5
20	73	117	186	236	288	60.0	68.0	71.0	68.0	60.0
21	55	105	173	224	303	53.0	63.0	67.5	67.0	57.0
22	77	125	195	260	298	59.5	71.0	75.0	73.5	59.0
23	47	115	162	210	266	58.5	70.0	74.5	76.0	66.0
24	69	128	177	219	282	62.0	75.0	78.5	75.0	66.0
25	105	143	170	212	282	54.0	68.0	72.5	74.5	63.5
26	71	133	181	231	289	84.0	100.0	104.5	99.0	80.5
27	59	139	187	237	293	46.0	56.0	58.5	60.0	47.0
28	77	124	182	225	287	55.0	70.0	76.0	70.0	57.0
29	75	118	187	248	293	69.0	75.0	68.5	56.5	49.0
30	64	128	175	224	305	47.0	61.5	63.0	60.0	47.5
31	72	135	178	223	293	75.5	80.5	76.5	71.5	68.0
32	72	119	182	232	291	60.0	69.0	76.5	73.5	64.5
33	87	141	180	219	282	85.5	96.0	101.5	99.5	79.5
34	55	136	184	225	300	46.0	64.0	67.5	64.0	46.0
35	72	142	185	252	290	60.0	71.5	80.0	73.5	59.0
36	84	140	188	237	279	56.5	73.0	69.0	67.0	57.0
37	56	117	183	244	290	64.5	80.0	85.0	82.5	67.5
38	81	123	181	218	287	63.0	86.0	93.0	84.0	63.5
39	92	141	175	211	276	58.5	76.0	81.5	75.5	64.0
40	65	123	171	232	291	63.0	82.5	86.5	84.5	69.0
41	77	129	180	230	289	54.5	62.5	67.5	62.5	54.0
42	46	118	176	248	308	61.0	79.0	86.0	79.0	67.5
43	87	133	173	235	281	64.0	82.0	86.5	81.0	71.5
44	57	119	184	235	300	46.0	72.0	74.5	69.0	51.5
Av.	**70°.5**	**129°.7**	**179°.5**	**229°.1**	**288°.3**	**65.8**	**80.0**	**83.6**	**80.1**	**66.4**
P. E. M.	±1°.51	±°.85	±°.68	±1°.22	±1°.07	±1.44	±2.93	±1.60	±1.71	±1.47

Date of Measurement = May 23, 1902.
Av. = Average.
P. E. M. = Probable Error of the Mean.

TABLE II.

PARTHENOCISSUS QUINQUEFOLIA. OPERATED SERIES. POSITION AND LENGTH OF LEAFLETS.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	(*D*)	*E*	*A*	*B*	*C*	(*D*)	*E*
1	100	155	220		279	73.0	81.0	79.0		65.0
2	85	139	207		279	46.5	46.5	55.5		47.0
3	82	141	206		299	57.5	65.0	70.0		68.0
4	85	133	207		279	58.0	69.0	76.0		62.5
5	71	142	231		286	63.5	71.5	77.5		65.5
6	83	142	202		270	60.5	68.0	69.0		58.0
7	61	141	192		289	50.0	64.0	70.0		52.5
8	74	146	193		276	49.5	65.0	71.5		52.0
9	72	128	222		274	33.0	47.0	45.0		31.0
10	56	140	195		260	62.5	74.0	82.0		67.0
11	63	113	200		274	59.5	70.0	77.5		58.0
12	92	142	228		279	55.5	67.5	76.5		54.5
13	73	134	195		299	67.0	88.0	96.0		64.0
14	93	148	207		295	63.5	89.0	100.0		67.0
15	73	139	196		288	58.5	73.5	80.5		59.0
16	97	164	216		314	78.5	102.0	103.0		79.0
17	79	140	198		280	60.0	74.0	73.0		60.5
18	98	154	196		267	76.0	91.5	105.5		81.0
19	104	160	199		265	75.5	87.5	97.0		78.5
20	58	131	205		287	56.5	73.0	79.5		58.0
21	64	155	226		288	40.0	55.5	60.5		55.0
22	68	133	192		277	91.0	102.0	110.5		80.5
23	69	132	210		330	55.0	66.5	70.0		50.0
24	93	170	224		286	74.5	84.0	88.5		74.0
25	95	158	199		288	68.0	75.0	83.0		62.5
26	76	135	187		281	75.0	87.5	87.5		71.0
27	56	144	195		289	57.0	66.0	71.0		44.5
28	78	149	192		275	84.5	97.0	97.5		51.5
29	78	134	195		275	76.0	83.5	95.0		76.5
30	56	138	184		262	50.0	60.5	66.0		52.5
31	85	152	208		294	51.0	70.5	72.5		56.0
32	83	134	183		259	64.5	84.0	86.0		67.5
33	79	137	212		281	65.5	75.5	72.5		63.0
34	74	139	211		290	52.0	59.0	67.5		47.0
35	79	139	197		287	73.0	95.0	98.0		76.5
36	74	123	193		300	89.0	99.0	105.5		84.0
37	58	114	185		273	52.5	67.5	72.5		58.0
38	88	160	200		277	66.5	84.5	89.0		64.5
39	45	139	197		312	51.0	66.5	69.5		48.0
40	84	157	198		287	83.0	95.5	95.0		80.0
41	70	134	179		287	54.5	66.0	64.5		51.0
42	79	146	198		284	87.0	98.0	96.0		86.0
43	44	129	194		312	42.0	56.0	60.5		43.0
44	98	158	211		294	89.5	105.5	109.0		83.0
45	84	140	182		294	86.0	103.0	108.5		84.0
46	88	132	186		308	59.0	77.0	74.0		50.5
47	73	141	200		293	50.0	62.0	67.5		50.0
48	74	168	229		298	48.0	59.0	63.0		46.5
49	55	114	199		281	48.5	63.0	65.5		51.0
50	75	135	198		293	55.5	68.5	76.5		60.0
51	71	123	190		268	41.0	57.0	64.5		47.0

TABLE II.—(*Continued.*)

PARTHENOCISSUS QUINQUEFOLIA. OPERATED SERIES. POSITION AND LENGTH OF LEAFLETS.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	(*D*)	*E*	*A*	*B*	*C*	(*D*)	*E*
52	43	123	199		273	45.5	58.5	65.0		65.5
53	96	157	211		270	55.5	72.0	80.0		60.5
54	83	147	202		244	56.5	71.5	73.5		53.5
55	69	123	226		285	60.5	79.0	83.0		59.0
56	80	153	224		255	49.0	61.5	60.5		47.5
57	85	157	228		280	45.0	56.0	61.5		46.5
58	98	158	222		342	43.0	66.5	70.0		46.5
59	49	129	195		278	55.0	65.0	74.0		58.5
60	63	142	221		298	59.0	73.0	80.0		58.5
61	82	139	201		287	52.5	64.5	70.0		51.0
62	84	158	214		280	63.0	78.0	82.5		63.5
63	88	153	206		276	66.0	79.5	80.5		61.0
64	60	146	223		278	80.5	99.0	107.0		75.0
65	89	148	194		311	50.0	74.0	82.0		53.0
66	74	125	220		294	48.5	62.5	65.5		45.5
67	84	156	203		286	71.0	83.5	88.5		71.0
Av.	**76°.4**	**141°.9**	**208°.9**		**285°.1**	**61.0**	**74.6**	**79.3**		**60.6**
P.E.M.	±1°.21	±1°.17	±1°.08		±1°.31	±1.13	±1.15	±1.26		±1.00

Date of Operation = April 23, 1902.
Date of Measurement = May 23, 1902.
Intervening Time = 30 days.
Av. = Average.
P. E. M. = Probable Error of the Mean.

Table III.

Trifolium pratense. Normal Series. Position and Length of Leaflets.

Leaf No.	Position (in Degrees).			Length (in Millimeters).		
	X	*Y*	*Z*	*X*	*Y*	*Z*
1	91	178	264	25.0	25.0	23.0
2	103	172	255	33.5	34.5	32.0
3	89	179	262	24.0	26.0	24.0
4	87	177	269	26.5	26.0	26.5
5	94	180	265	23.0	24.0	26.5
6	88	176	269	27.0	25.5	25.0
7	91	173	262	24.5	27.5	27.0
8	60	168	275	22.5	20.5	19.5
9	14	145	254	16.5	17.5	16.5
10	45	134	234	13.0	15.5	14.0
11	84	169	250	31.5	33.0	31.0
12	62	150	248	22.0	22.5	22.5
13	96	159	240	29.5	31.0	31.5
14	78	170	242	32.5	36.0	35.0
15	73	175	250	24.0	25.5	27.5
16	105	180	257	28.0	26.0	24.0
17	67	181	286	17.5	17.0	16.5
18	31	133	225	21.0	23.5	23.5
19	67	175	284	21.0	20.0	21.5
20	72	177	278	27.0	25.0	25.5
21	42	132	261	13.5	14.0	16.0
22	102	184	261	23.5	24.0	23.0
23	98	186	265	28.0	27.5	28.5
24	107	202	293	19.5	21.5	22.0
25	104	184	262	22.5	24.0	28.0
26	101	190	246	18.0	16.5	17.0
27	95	187	273	22.5	23.5	23.0
28	49	153	288	26.5	26.0	27.5
29	95	193	280	23.5	21.5	21.5
30	123	214	315	25.5	23.5	21.0
31	49	146	293	22.5	24.5	23.5
Av.	**79.4°**	**171.7°**	**264.7°**	**23.7**	**24.1**	**24.0**
P. E. M.	$\pm 3.09^\circ$	$\pm 2.35^\circ$	$\pm 2.34^\circ$	$\pm .59$	$\pm .65$	$\pm .63$

Date of Measurement = May 5, 1902.

Av. = Average.

P. E. M. = Probable Error of the Mean.

Table IV.

Trifolium pratense. Operated Series. Position and Length of Leaflets.

Leaf No.	Position (in Degrees).			Length (in Millimeters).		
	X	Y	(Z)	X	Y	(Z)
1	120	229		27.5	27.0	
2	48	135		20.0	20.0	
3	73	169		27.5	26.5	
4	78	185		19.0	17.0	
5	115	237		24.0	22.0	
6	103	210		18.5	19.5	
7	68	177		31.0	31.0	
8	120	234		26.5	28.0	
9	88	196		31.0	30.5	
10	136	226		24.5	25.0	
11	109	215		14.5	15.0	
12	70	192		20.0	19.5	
13	67	163		19.5	17.5	
14	114	224		16.0	17.0	
15	76	179		12.5	13.5	
16	117	214		16.5	15.0	
17	100	218		12.0	11.5	
18	131	240		15.5	15.0	
19	38	137		13.0	11.0	
20	81	207		20.0	21.0	
21	118	220		33.0	35.5	
22	88	174		19.5	18.0	
23	153	268		6.5	6.5	
24	136	224		16.5	16.0	
25	138	238		31.5	29.0	
26	79	212		21.5	20.5	
27	92	209		24.0	23.5	
28	83	201		19.5	21.5	
29	53	181		18.0	19.5	
30	64	178		14.5	15.0	
31	95	207		16.5	17.0	
32	85	245		12.0	11.5	
33	98	203		22.5	23.0	
34	79	181		31.5	32.0	
35	123	189		14.5	14.0	
36	105	211		27.0	26.5	
37	71	152		22.0	22.0	
38	111	215		23.0	26.0	
39	62	178		22.5	25.0	
40	85	198		25.5	27.5	
41	118	200		38.5	39.0	
42	114	209		23.0	22.0	
43	105	182		30.0	30.5	
44	100	180		35.5	35.5	
45	113	200		30.0	29.5	
46	148	253		20.0	20.0	
47	160	233		18.5	18.5	
48	77	195		20.5	21.0	
49	68	160		15.5	15.0	
50	102	188		23.5	22.0	
51	60	165		22.0	22.5	

Table IV.—*Continued.*

Trifolium pratense. Operated Series. Position and Length of Leaflets.

Leaf No.	Position (in Degrees).			Length (in Millimeters).		
	X	Y	(Z)	X	Y	(Z)
52	90	182		29.5	28.5	
53	39	202		22.0	22.0	
54	169	280		22.0	23.5	
55	144	280		16.0	17.0	
56	100	176		22.0	24.5	
57	90	180		25.0	24.5	
58	100	195		28.0	27.0	
59	99	194		22.0	22.0	
60	101	177		20.5	21.5	
61	120	189		32.5	30.5	
62	65	160		13.5	13.5	
63	111	204		28.0	27.5	
64	103	205		28.5	28.0	
65	113	213		28.0	27.0	
66	106	194		32.0	28.0	
67	103	186		14.0	14.5	
68	132	209		18.0	20.0	
69	87	180		25.0	28.0	
70	114	189		26.5	27.0	
71	120	207		28.0	26.5	
72	99	175		21.5	26.0	
73	59	180		15.5	16.5	
74	88	228		19.0	21.0	
75	95	184		32.5	31.0	
76	112	209		19.5	19.5	
77	105	235		21.0	23.0	
78	78	173		21.5	22.0	
79	74	210		26.0	27.5	
80	22	116		22.5	22.5	
81	116	220		24.0	25.0	
82	130	220		20.5	23.0	
83	103	293		27.5	26.0	
84	86	186		21.0	23.0	
85	52	153		20.0	19.0	
86	108	228		13.0	14.5	
87	103	189		20.5	21.0	
Av.	**96.2°**	**200.4°**		**22.2**	**22.4**	
P.E.M.	±2.00°	±2.20°		±.47	±.46	

Date of Operation = April 14, 1902.
Date of Measurement = May 5, 1902.
Intervening Time = 21 days.
P. E. M. = Probable Error of the Mean.
Av. = Average.

TABLE V.

LUPINUS ALBUS. NORMAL SERIES. POSITION AND LENGTH OF LEAFLETS.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	*D*	*E*	*A*	*B*	*C*	*D*	*E*
1	54	122	177	248	327	28.4	33.7	34.9	35.1	26.8
2	53	125	185	243	302	27.2	31.2	32.9	31.4	27.6
3	68	123	186	244	300	22.5	27.6	31.5	26.0	21.1
4	46	127	187	247	315	30.2	31.2	32.2	32.1	31.7
5	43	94	165	219	283	24.2	29.1	29.8	28.2	24.1
6	48	114	176	250	315	25.3	32.4	34.3	30.8	26.7
7	61	122	183	238	290	26.2	28.9	32.5	33.3	26.7
8	55	110	183	250	287	27.2	34.3	35.6	32.8	28.2
9	57	108	167	224	294	22.4	25.3	28.6	26.7	21.7
10	34	96	170	252	317	25.9	30.0	32.4	31.2	27.3
11	59	112	182	257	301	25.1	31.0	31.7	31.4	26.3
12	62	113	174	247	302	27.0	30.9	32.4	29.6	25.4
13	63	117	186	251	301	20.6	25.8	28.5	28.5	22.7
14	56	108	175	235	292	26.9	30.8	30.8	29.5	26.5
15	83	142	208	254	330	23.1	28.5	29.5	27.2	21.7
16	52	103	172	246	318	26.3	29.1	30.4	30.3	25.8
Av.	**55°.9**	**114°.7**	**179°.7**	**244°.1**	**304°.6**	**25.5**	**30.0**	**31.7**	**30.3**	**25.6**
P.E.M.	±1°.9	±2°.1	±1°.8	±1°.8	±2°.6	±.43	±.40	±.35	±.45	±.40

Date of Measurement = March 24, 1902.
P. E. M. = Probable Error of the Mean.
Av. = Average.

Table VI.

Lupinus albus. Operated Series. Position and Length of Leaflets.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	(*D*)	*E*	*A*	*B*	*C*	(*D*)	*E*
1	60	128	227		302	25.9	30.8	30.9		25.9
2	86	142	218		321	28.4	31.9	33.8		25.7
3	92	160	226		318	23.3	27.8	28.2		21.3
4	142	235	302		78	30.5	27.6	23.4		27.2
5	119	171	233		47	31.4	34.8	30.7		25.6
6	270	38	122		200	29.3	26.5	32.3		32.8
7	337	48	113		260	24.0	28.0	30.0		23.2
8	171	231	299		87	29.4	28.1	22.8		26.9
9	114	195	266		15	25.1	28.4	27.3		18.3
10	98	172	239		37	23.0	27.3	27.7		19.5
11	62	145	230		313	17.7	22.8	23.5		19.0
12	68	139	214		305	26.8	31.9	30.8		24.7
13	62	123	196		305	22.1	26.9	28.8		25.7
14	83	153	219		338	22.3	24.4	22.7		18.8
15	335	39	106		230	23.8	29.9	29.6		20.1
16	50	118	198		278	21.2	26.6	31.9		21.8
17	92	191	268		28	19.1	22.8	26.4		20.2
18	42	108	179		280	24.0	31.8	32.3		30.0
19	309	82	134		226	20.0	25.8	28.7		26.2
20	34	118	199		302	19.7	26.0	28.7		24.0
21	9	95	163		264	19.5	29.4	33.0		28.0
22	56	115	204		293	31.0	35.5	33.4		21.9
23	46	118	219		327	23.5	26.2	28.3		18.9
24	25	115	197		265	30.3	37.7	37.5		27.0
25	94	163	237		315	23.2	27.7	27.1		21.3
26	55	129	191		291	22.0	25.0	25.5		21.8
27	125	179	243		63	28.0	29.3	31.7		24.5
28	126	220	305		45	21.4	25.9	26.4		23.2
29	36	86	178		286	26.0	27.0	27.7		26.0
30	62	125	186		292	17.8	21.0	23.8		23.3
31	84	154	233		17	26.3	25.2	29.3		25.1
32	72	132	204		312	25.0	25.1	27.9		23.7
33	62	142	220		321	22.7	26.6	25.9		22.2
34	64	122	188		305	30.8	33.3	34.6		21.7
35	65	125	190		296	22.6	23.7	27.8		22.8
36	59	127	230		310	18.7	23.7	24.9		20.0
37	70	110	193		313	22.2	26.6	30.6		24.9
38	75	138	206		318	28.3	33.2	32.7		23.6
39	64	117	182		330	25.7	28.0	31.6		29.8
40	57	134	221		344	19.6	24.9	27.7		24.1
41	134	212	267		40	31.8	33.2	36.6		31.9
42	250	315	69		207	21.3	19.7	27.0		24.9
43	325	75	133		233	21.1	29.3	29.6		22.5
44	54	136	203		321	23.3	26.6	28.0		20.3
45	342	55	159		285	22.3	27.1	27.1		25.0
46	59	131	210		314	23.3	28.3	31.4		20.1
47	325	76	157		241	22.0	25.9	26.8		23.9
48	120	176	224		52	21.6	24.4	28.6		21.1
49	23	102	161		283	25.7	31.8	32.6		25.1
50	77	153	238		323	26.0	28.4	30.0		21.9
51	47	124	204		331	21.7	26.8	25.0		20.8

Table VI.—*Continued.*

LUPINUS ALBUS. OPERATED SERIES. POSITION AND LENGTH OF LEAFLETS.

Leaf No.	Position (in Degrees).					Length (in Millimeters).				
	A	*B*	*C*	(*D*)	*E*	*A*	*B*	*C*	(*D*)	*E*
52	42	115	175		275	27.7	32.7	37.3		25.3
53	334	76	162		265	20.5	25.0	29.7		21.4
Av.	**53.2°**	**126.0°**	**203.0°**		**313.8°**	**24.1**	**27.8**	**29.2**		**23.7**
P.E.M.	±5.1°	±4.5°	±4.2°		±5.3°	±.34	±.34	±.33		±.30

Date of Operation = February 11, 1902.
Date of Measurement = March 24, 1902.
Intervening Time = 41 days.
Av. = Average.
P. E. M. = Probable Error of the Mean.

The Results.

The changes produced in the leaf-system as a result of the removal of one leaflet may be conveniently grouped under three heads:

1. Changes in the *position* of the leaflets.
2. Changes in the *intervals* between the leaflets.
3. Changes in the *length* of the leaflets.

Under each of these three heads we will consider, first the changes in *Parthenocissus*, then in *Trifolium* and finally in *Lupinus*. This is not the chronological order of the experiments, but is preferable to the latter because of the complex relations found to exist in the last-mentioned species.

Changes in the Position of the Leaflets.

Parthenocissus quinquefolia.— Uniting and comparing the average positions as found in Tables I and II we get the changes shown in Table VII. *A* has moved 5.9° in a clockwise (+) direction, *B* 12.2° and *C* 24.4° in the same direction while *E* has moved a short distance (3.2°) in an anti-clockwise (—) direction. It will be noticed that the sum of the probable errors is in each case well below the difference of the averages. The whole change in the leaf system is graphically shown in *f. 6*, in which the leaflet positions are carefully drawn to scale,

TABLE VII.

PARTHENOCISSUS QUINQUEFOLIA. CHANGE OF POSITION OF LEAFLETS.

	A	*B*	*C*	*D*	*E*
Normal Series.	$70.5^\circ \pm 1.51^\circ$	$129.7^\circ \pm .85^\circ$	$179.5^\circ \pm .68^\circ$	$229.1^\circ \pm 1.22^\circ$	$288.3^\circ \pm 1.07^\circ$
Operated Series.	76.4 ± 1.21	141.9 ± 1.17	203.9 ± 1.08		285.1 ± 1.31
Difference = Change of Position.	**$+5.9^\circ$**	**$+12.2^\circ$**	**$+24.4^\circ$**		**-3.2°**
Σ P. E. M.	$\pm 2.7^\circ$	$\pm 2.0^\circ$	$\pm 1.8^\circ$		$\pm 2.4^\circ$

Σ P. E. M. = Sum of the Probable Errors of the Normal and Operated Series.

the unbroken lines representing the average normal positions and the broken lines the average operated positions. Two interesting points are brought out by a study of this diagram. In the first place, *the changes are evidently in some way con-*

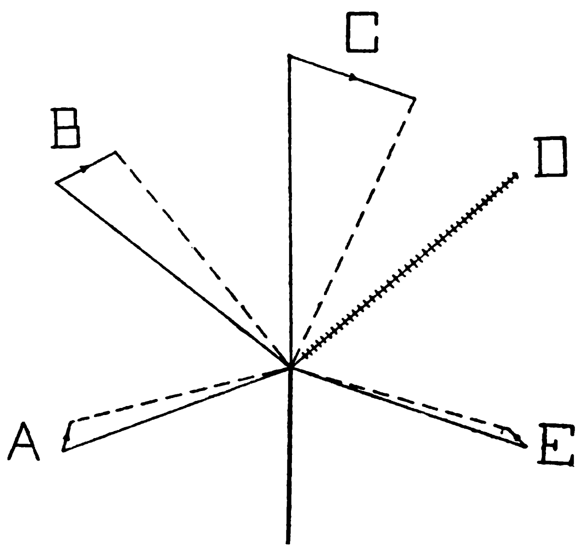


FIG. 6. (One half natural size.) ***Parthenocissus quinquefolia.*** **Average normal (unbroken lines) and average operated (dotted lines) position and length of leaflets.**

nected with the closing up of the gap left after the removal of leaflet D. If this were the only factor we would expect the closing up to take place symmetrically from the two sides. Thus we ought to get a large plus motion in *C* and *B*

and a correspondingly large minus motion in *E* and *A*. Instead of this we find practically all the changes in *C* and *B*. *E* shows only a very slight minus motion while *A* shows a slight plus motion. This brings us to the second point: *the change of position is almost entirely confined to the leaflets which are left in an unsymmetrical position with respect to the petiole axis and the change in them is directed toward the production of a four-leaved symmetrical figure.*

Trifolium pratense. — The changes here are obtained by a comparison of the averages in Tables III and IV. We find (Table VIII) a motion of $+28.7^\circ$ in leaflet *Y* as a result of the operation and a motion of $+16.8^\circ$ in leaflet *X*. As be-

Table VIII.

Trifolium pratense. Change of Position of Leaflets.

	X	*Y*	*Z*
Normal Series.	$79.4^\circ \pm 3.09^\circ$	$171.7^\circ \pm 2.35^\circ$	$264.7^\circ \pm 2.34^\circ$
Operated Series.	96.2 ± 2.00	200.4 ± 2.20	
Difference = Change of Position.	$+16.8^\circ$	$+28.7^\circ$	
Σ P. E. M.	$\pm 5.09^\circ$	$\pm 4.55^\circ$	

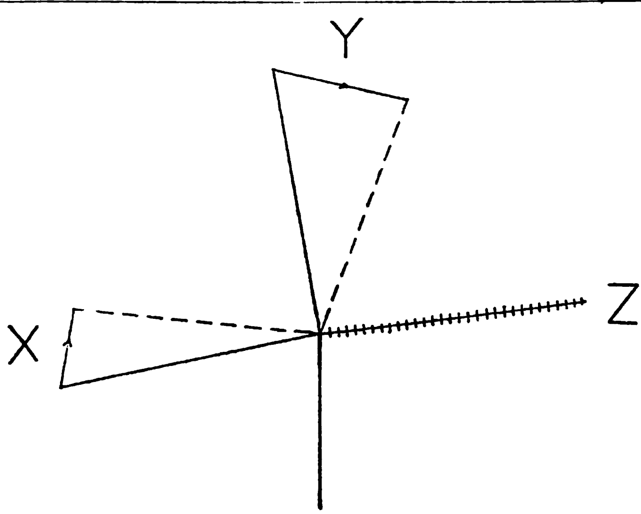


Fig. 7. **(× 1½.)** ***Trifolium pratense.*** **Average normal (unbroken lines) and average operated (dotted lines) position and length of leaflets.**

fore, the sums of the probable errors of the averages are well below the changes of position. A graphical representation of these changes is given in *f. 7*. Both of the leaflets remaining after the operation show a considerable movement in a clockwise direction. The removal of leaflet *Z* left the other two leaflets unsymmetrical with respect to the petiole axis. Their condition therefore corresponds in all essential points with that of leaflets *C* and *B* of *Parthenocissus* and in like manner we find that the change in leaflet *Y* is very similar to that in *C*, while the change in *X* is similar to that in *B*. *We may therefore here also consider the regulation as a step toward the production of a symmetrical system, a two-leaved one in this case.*

Lupinus albus. — A comparison of the averages in Tables V and VI gives us a change in position of $+23.3^\circ$ in *C*, $+11.3^\circ$ in *B*, -2.7° in *A*, and $+9.2^\circ$ in *E* (Table IX). Here as before the sum of the probable errors is considerably

TABLE IX.

LUPINUS ALBUS (ALL CASES). CHANGE OF POSITION OF LEAFLETS.

	A	*B*	*C*	*D*	*E*
Normal Series. Operated Series.	$55.9^\circ \pm 1.9^\circ$ 53.2 ± 5.1	$114.7^\circ \pm 2.1^\circ$ 126.0 ± 4.5	$179.7^\circ \pm 1.8^\circ$ 203.0 ± 4.2	$244.1^\circ \pm 1.8^\circ$	$304.6^\circ \pm 2.6^\circ$ 313.8 ± 5.3
Difference = Change of Position.	-2.7°	$+11.3^\circ$	$+23.3^\circ$		$+9.2^\circ$
Σ P. E. M.	$\pm 7.0^\circ$	$\pm 6.6^\circ$	$\pm 6.0^\circ$		$\pm 7.9^\circ$

less than the difference of the averages in *C* and *B*, but in *A* it is greater than the difference and in *E* it is very nearly equal to the difference. An examination of Table VI shows us a great lack of uniformity in the resultant positions of the leaflets and the unusually large probable errors are due to this fact. The leaflets have in many cases moved forward or backward over the surface of the petiole and as a result we have a mass of figures which at first sight seems impossible of resolution into uniform data, but a closer study enables us to get at some points which are perhaps the most interesting of all those made out in these experiments. It

may be well again to emphasize the fact that there is no doubt of this wide range of movement, because the scar of the removed leaflet in all cases served as a point of orientation in determining the identity of the leaflets.

Before going on with the analysis of Table VI let us take the averages as they stand. Considering the great range of positions which the operated series includes the differences of the averages show a striking similarity to those of *Parthenocissus.* In fact leaflets *C* and *B* show almost identical movements in the two cases. In *A* and *E* however the con-

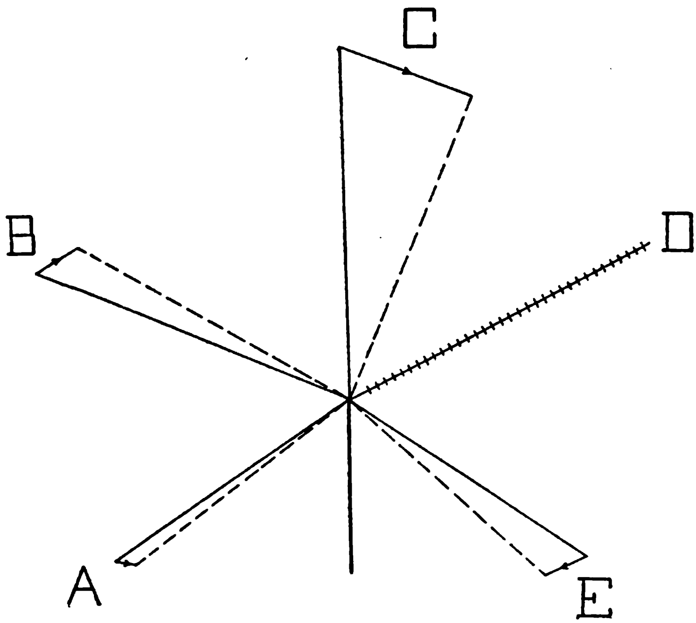


FIG. 8. ($\times$ 1⅝.) ***Lupinus albus*** **(all cases). Average normal (unbroken lines) and average operated (dotted lines) position and length of leaflets. (The dotted line at *B* is incorrectly placed; it should be 11.3° from the unbroken line.)**

siderable number of cases in which the leaflets have moved over the surface of the petiole has left a minus influence in *A* and a plus influence in *E* (see *f. 8*), but in neither *A* nor *E* is the change sufficient to destroy the general similarity to *Parthenocissus* and *we have here the same tendency toward the production of a symmetrical four-leaved system.*

Let us turn now to the analysis of the apparently complex data of Table VI. In the operated series of *Parthenocissus* and *Trifolium* we found no case of the rotation of a leaflet over the surface of the petiole. In *Lupinus*, however, we find 20 such cases out of a total of 53, leaving only 33 in which the leaflets retain the normal relation. A further examination of the 20 former cases shows us that in eleven the rotation has brought the petiole into the interval between *C* and *E*, in eight into the interval *AB*, and in one into the interval *BC*. It is moreover found that the leaflets in their rotation either stop far short of the petiole or else go a considerable distance past it, and as the movement of the particular leaflet which is nearest to the petiole is involved in the movement of the leaf system as a whole, we get four marked maxima of position corresponding to the four different inter-

TABLE X.

LUPINUS ALBUS (MINOR ROTATIONS). CHANGE OF POSITION OF LEAFLETS.

	A	*B*	*C*	*D*	*E*
Normal Series.	$55.9^\circ \pm 1.9^\circ$	$114.7^\circ \pm 2.1^\circ$	$179.7^\circ \pm 1.8^\circ$	$244.1^\circ \pm 1.8^\circ$	$304.6^\circ \pm 2.6^\circ$
Operated Series. Petiole in *EA* (33 cases).	57.9 ± 2.0	126.9 ± 1.9	203.2 ± 2.4		305.8 ± 2.3
Difference = Change of Position.	**$+2.0^\circ$**	**$+12.2^\circ$**	**$+23.5^\circ$**		**$+1.2^\circ$**
2 P. E. M.	$\pm 3.9^\circ$	$\pm 4.0^\circ$	$\pm 4.2^\circ$		$\pm 4.9^\circ$

Minor Rotations = Cases in the operated series of *Lupinus albus* in which the petiole retains its position in *EA*.

vals occupied by the petiole. The significance of the tendency of the leaflets to avoid a position directly above the petiole will be discussed more fully in our consideration of the change in the value of the intervals. At present it is only necessary to bring out the fact that the 33 operated cases in which the normal relations are retained and which will be called the cases of minor rotation, correspond to the whole series of operated cases in *Parthenocissus* and therefore serve as a more rational basis of comparison. Taking the averages of the normal series of *Lupinus* as found in Table V

and comparing with them the averages of the 33 cases of minor rotation in Table VI, we get the results shown in Table X.

We see here that the changes in the position of *A* and *E* are very slight, in fact within the sum of the probable errors of the averages. On the other hand the changes in *B* and *C* are almost identical with those of the corresponding leaflets in *Parthenocissus*. *F. 9* gives the changes in diagrammatic form.

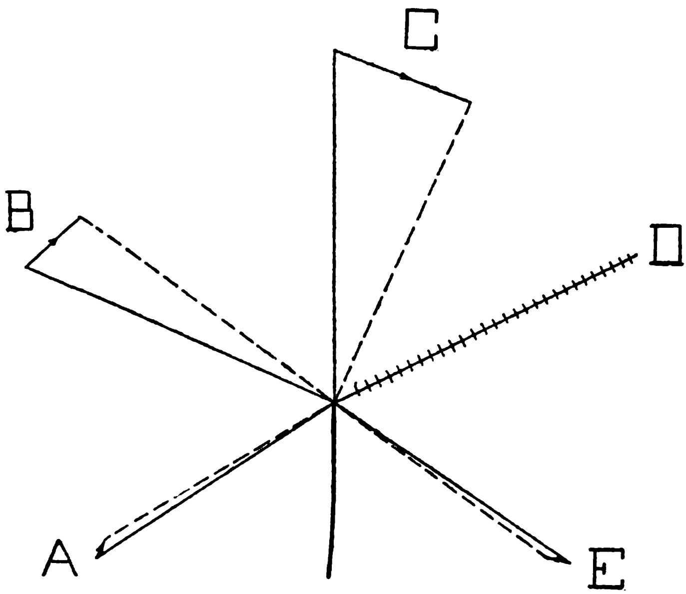


FIG. 9. (× 1½.) *Lupinus albus* (minor rotations only). Average normal (unbroken lines) and average operated (dotted lines) position and length of leaflets.

To sum up the change of position in the leaflets as a result of the removal of one of their number we find, first, *that there is a movement tending to close up the large interval left by the operation* and, second, *that this movement is almost entirely confined to the two leaflets left in an unsymmetrical position as a direct result of the operation*. Further, in these two leaflets the movement in the one nearest to the cut is approximately twice as great as in the other, a condition which in the five-leafed forms would lead to an equal increase in the intervals *AB* and *BC* if leaflet *A* remained stationary.

Changes in the Intervals between the Leaflets.

From the average positions in Tables I to VI we are able to determine the average values of the intervals between the leaflets in the different cases. This enables us to get at the changes in the intervals as a result of the operation. As stated before, the changes in position seem to be aimed at a closing up of the large interval left by the removed leaflet. A study of the interval changes throws some further light on this point. *F. 6, 7, 8* and *9* show us these changes in diagrammatic form and should be referred to in the following discussion. The average values of the intervals in *Parthenocissus* as obtained from Tables I and II are shown in Table XI, in which each of the intervals is designated by the two leaflets

TABLE XI.

PARTHENOCISSUS QUINQUEFOLIA. CHANGE IN THE INTERVALS BETWEEN THE LEAFLETS.

	AB	*BC*	*CD + DE = CE*	*EA*
Normal Series.	59.2°	49.8°	49.6° + 59.2° = 108.8°	142.2°
Operated Series.	65.5°	62.0°	81.2°	151.3°
Diff. = Change in Interval.	**+6.3°**	**+12.2°**	**−27.6°**	**+9.1°**

which form its boundaries. We see that the interval *CE* has been decreased by 27.6°, the decrease being accompanied by an increase in *AB* of 6.3°, in *BC* of 12.2° and in *EA* of 9.1°.

Trifolium pratense.—Table XII gives us the values of the intervals as obtained from Tables III and IV. The results show a decrease of 11.9° in the interval *YX* and a like increase in *XY*.

TABLE XII.

TRIFOLIUM PRATENSE. CHANGE IN THE INTERVALS BETWEEN THE LEAFLETS.

	XY	*YZ + ZX = YX*
Normal Series.	92.3°	93.0° + 174.7° = 267.7°
Operated Series.	104.2°	255°.8
Diff. = Change in Interval.	**+11.9°**	**−11.9°**

Lupinus albus. — In considering the intervals here we have obviously the same difficulties encountered in dealing with the positions. Here also the average of all the operated cases will be dealt with first and this will be followed by a treatment of the special cases. From the general averages of Tables V and VI we get the intervals shown in Table XIII. Taking into consideration in the operated series only the 33

TABLE XIII.

LUPINUS ALBUS (ALL CASES). CHANGE IN THE INTERVALS BETWEEN THE LEAFLETS.

	AB	*BC*	*CD + DE = CE*	*EA*
Normal Series.	58.8°	65.0°	64.4° + 60.5° = 124.9°	111.3°
Operated Series.	72.8°	77.0°	110.8°	99.4°
Difference = Change in Interval.	**+14.0°**	**+12.0°**	**— 14.1°**	**—11.9°**

cases in which the petiole remains in the interval *EA*, we get the results given in Table XIV.

TABLE XIV.

LUPINUS ALBUS (MINOR ROTATIONS). CHANGE IN THE INTERVALS BETWEEN THE LEAFLETS.

	AB	*BC*	*CD + DE = CE*	*EA*
Normal Series.	58.8°	65.0°	64.4° + 60.5° = 124.9°	111.3°
Operated Series. Petiole in *EA* (33 cases).	69.0°	76.3°	102.6°	112.1°
Difference = Change in Interval.	**+10.2°**	**+11.3°**	**— 22.3°**	**+.8°**

The changes in the intervals as brought out by the differences between the averages in the cases of minor rotation and the normal cases (Table XIV and *f. 9*) show a very close approximation to a condition in which nearly all the rotation has been confined to *B* and *C* and in which *C* has moved twice as far as *B*. Such a rotation would, as stated on page 157, give us an equal increase in intervals *AB* and *BC* and no change in interval *EA*. Here we get an increase of 10.2° in *AB*, of 11.3° in *BC*, and of .8° in *EA*, a very close agreement indeed. In *Parthenocissus* a similar result is not ob-

tained because of a considerable plus movement of *A* and minus movement of *E*, the two combining to increase the interval *EA* (see Tables VII and XI and *f. 6*).

When we take all the operated cases of *Lupinus* into consideration (Table XIII) the regulations concerned in the closing of interval *CE* are confused by the effect of the petiole position upon the intervals which come under its influence. As stated above (page 156) the leaflets show a marked tendency either to stop far short of the petiole or to swing considerably beyond it. A preliminary glance is sufficient to show the great influence this must have upon the value of an interval containing the petiole. The value of the interval *EA* in the 33 operated cases, in which the petiole remains there is 112.1° (Table XIV). Adding to these the 20 cases in which the petiole has moved away we get an average for the whole 53 cases of 99.4°, a clear decrease of 12.7° even in this mixed lot (Table XIII). If now we get the value of each interval, first in the cases in which it contains the petiole

TABLE XV.

LUPINUS ALBUS. DETERMINATION OF THE VALUE OF THE PETIOLE FACTOR.

		AB	*BC*	*CE*	*EA*
Cases not including Petiole in Interval. (Group *A*.)	No. of Cases. Average of Intervals.	45 70°	52 74°	42 104°	20 75°
Cases including Petiole in Interval. (Group *B*.)	No. of Cases. Average of Intervals.	8 99°	1 114°	11 145°	33 112°
Group B — Group A = Petiole Factor.		**+29°**	**+40°**	**+41°**	**+37°**
Average Value of Petiole Factor.	**+37°**				

and then in the cases in which the petiole is elsewhere, the difference between the two values should, other things being equal, give us the influence of the petiole upon the interval. Such a scheme is given in Table XV, which gives first the values of the respective intervals when they do not contain the petiole and then the values with the petiole. The second

group minus the first gives us *the increase due to the presence of the petiole* or, in other words, *the petiole factor*. *By this means we arrive at a value of approximately* $+ 37°$, *which represents the increase in an interval as a result of the presence of the petiole within it.* Considering the character of the experiments the similarity in the values obtained from the different intervals is very striking. Thus we get 29° from the interval *AB*, 40° from *BC*, 41° from *CE* and 37° from *EA*. It should be noticed that in the last case, that of *EA*, where the distribution between the two groups is most even, we have the closest agreement with the average, as we should expect.

Changes in the Length of the Leaflets.

Parthenocissus quinquefolia.— A comparison of the lengths of the leaflets in the normal series with those in the operated series, is given in Table XVI, which is derived from Tables I and II. We find that each of the leaflets shows a considerable decrease and this decrease in each case is above the sum of the probable errors of the averages.

Trifolium pratense. — The changes in length as figured out from Tables III and IV are given in Table XVII. The general result is very similar to that obtained in *Parthenocissus* the percentage of decrease being nearly the same.

Lupinus albus.— The changes in length as figured out from Tables V and VI are given in Table XVIII. If we

TABLE XVI.

PARTHENOCISSUS QUINQUEFOLIA. CHANGE IN LENGTH OF LEAFLETS.
(MEASUREMENTS ARE IN MILLIMETERS.)

	A	*B*	*C*	*D*	*E*
Normal Series.	65.3 ± 1.44	80.0 ± 2.93	83.6 ± 1.60	80.1 ± 1.71	66.4 ± 1.47
Operated Series.	61.0 ± 1.13	74.6 ± 1.15	79.3 ± 1.26		60.6 ± 1.00
Difference = Change in Length.	—4.3	—5.4	—4.3		—5.8
ΣP E M.	±2.57	±4.08	±2.86		±2.47
Per cent. of Change.	**—6.6 %**	**—6.7 %**	**—5.1 %**		**—8.7 %**
Average Change.	**—6.8 %**				

Table XVII.

Trifolium pratense. Change in Length of Leaflets. (Measurements are in Millimeters.)

	X	*Y*	*Z*
Normal Series. Operated Series. Difference = Change in Length.	23.7 ± .59 22.2 ± .47 —1.5	24.1 ± .65 22.4 ± .46 —1.7	24.0 ± .63
2 P. E. M.	±1.06	±1.11	
Per cent. of Change.	**—6.3%**	**—7.1%**	
Average Change.	**—6.7%**		

Table XVIII.

Lupinus albus (All Cases). Change in Length of Leaflets. (Measurements are in Millimeters.)

	A	*B*	*C*	*D*	*E*
Normal Series. Operated Series. Difference = Change in Length.	25.5 ± .43 24.1 ± .34 —1.4	30.0 ± .40 27.8 ± .34 —2.2	31.7 ± .35 29.2 ± .33 —2.5	30.3 ± .45	25.6 ± .40 23.7 ± .30 —1.9
2 P. E. M.	±.77	±.74	±.68		±.70
Per cent. of Change.	**—5.5%**	**—7.3%**	**—7.9%**		**—7.4%**
Average Change.	**—7.0%**				

take only the cases of minor rotation in the operated series we get the changes shown in Table XIX. Although the values in the two tables are nearly alike it will be better

Table XIX.

Lupinus albus (Minor Rotations). Change in Length of Leaflets. (Measurements are in Millimeters.)

	A	*B*	*C*	*D*	*E*
Normal Series. (16 cases.)	25.5 ± .43	30.0 ± .40	31.7 ± .35	30.3 ± .45	25.6 ± .40
Operated Series. (33 cases.)	23.9 ± .41	28.2 ± .46	29.6 ± .44		23.4 ± .35
Difference = Change in Length.	— 1.6	— 1.8	— 2.1		— 2.2
2 P. E. M.	± .84	± .86	±.79		± .75
Percentage of Decrease.	**— 6.3 %**	**— 6.0 %**	**— 6.6 %**		**— 8.6 %**
Av. of all Leaflets.	**— 6.9 %**				

for the sake of comparison with the other species to take the values represented in Table XIX, as it will be seen later that there is some correlation between change of position and change of length. In *f. 6–9* we have a representation of the changes in length, in each of the four cases, together with the other features mentioned before.

Comparing the three species as regards the change in length we get an average decrease of 6.8 per cent. in *Parthenocissus*, of 6.7 per cent. in *Trifolium* and of 6.9 per cent. in *Lupinus* (7.0 per cent. in the last named if we consider all the cases). This gives us *an average decrease of 6.8 per cent. as the result of the removal.* When we take into consideration the striking uniformity in the results, the fact that in each case the difference representing the change is greater than the sum of the probable errors of the averages, and above all the care exercised in securing uniformity in the two series of one species, we must conclude that *the removal of one of the leaflets in the compound leaves of the three species mentioned directly inhibits the growth of the remaining leaflets.*

As was hinted above there is yet another matter concerning the changes in length which seems to be of great interest. This concerns again the operated series of *Lupinus albus* as given in Table VI. The great variety of rotations furnishes a basis for a consideration of the relation between the length of a leaflet and its position. We have shown in Table XVIII that the general averages of *Lupinus albus* exhibit a very uniform decrease when we compare the whole operated series with the normal one. What will be the result if we separate the cases into groups as already done in the treatment of the intervals? If the length of a leaflet is at all correlated with its position in the leaf-system may we not find some indication of it here? Obviously the differences with which we must deal in this case are dangerously near the sums of the probable errors of the averages, but if we get anything like uniformity in the different cases we should not hesitate to attach importance to the results.

Let us take first the 33 cases in which the petiole remains in *EA*, as already collected in Table XIX. The changes of position from the normal are here so slight that the group may serve as a basis for our comparison because we may consider any change of length to be unaffected by the addition of a factor due to change of position. The changes of position with which we shall have to deal are those involving a rotation from a more basal to a more terminal position or *vice versa*. Such changes may be most directly measured in terms of the cosine of the position angle. If x is the position angle an increase in the value of $1 - \cos x$ indicates a change from a more basal to a more terminal position, while a decrease indicates the opposite change. Fig. 10 illustrates

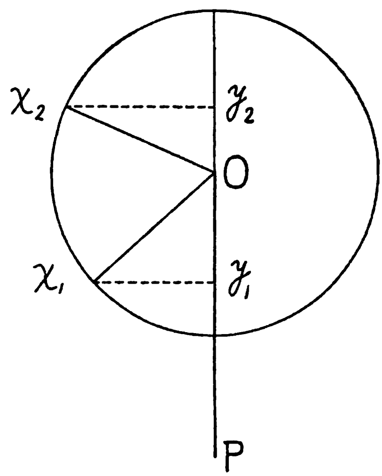


Fig. 10. Diagram to illustrate method of measuring the basal-terminal component of rotation. OP = petiole position. Ox_1 and Ox_2 = leaflet positions.

this in diagrammatic form. Thus if OP is the petiole position, Ox_1 the leaflet position in the normal series, and Ox_2 the leaflet position in the operated series, the change of position as regards the basal-terminal direction is represented by the distance $y_1y_2 = Oy_1 + Oy_2$ which may be obtained from the equation

$$(1 - \cos \angle x_2OP) - (1 - \cos \angle x_1OP) = y_1y_2.$$

The value is obviously a positive one in this case, while if Ox_2 represents the normal position and Ox_1 the operated position, the change is a negative one.

The data resulting from this treatment are given in Tables

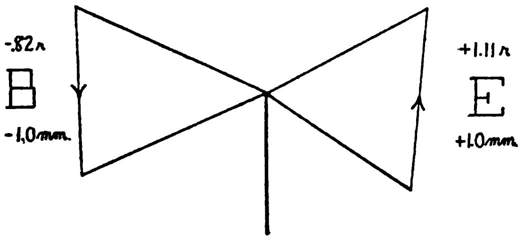


FIG. 11. (Natural size.) *Lupinus albus* (petiole in *AB*). Only two leaflets given. Original position (as shown by arrow) = average position in normal series and average length with petiole in *EA*. Final position = average position and length with petiole in *AB*. Number above leaflet letter = change of basal-terminal position. Number below = corresponding change in length.

XX, XXI and XXII. In each of these we have in the first place the length of the leaflets in the particular group in question compared with the normal length. Then we have the

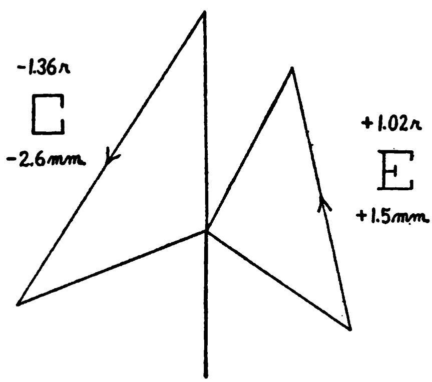


FIG. 12. (Natural size.) *Lupinus albus* (petiole in *BC*). Only two leaflets given. Original position (as shown by arrow) = average position in normal series and average length with petiole in *EA*. Final position = average position and length with petiole in *BC*. Number above leaflet letter = change of basal-terminal position. Number below = corresponding change in length.

average normal position and the average position in the operated group. Below these are the comparisons of the positions

which give us the basal-terminal change in terms of the radius of the circle of reference. Then comes a repetition of the length-changes in the group. Below this are the average changes of length in the cases where the petiole is in *EA*, which, as stated above, serve as the basis of comparison because they are uninfluenced by position factors. Finally we

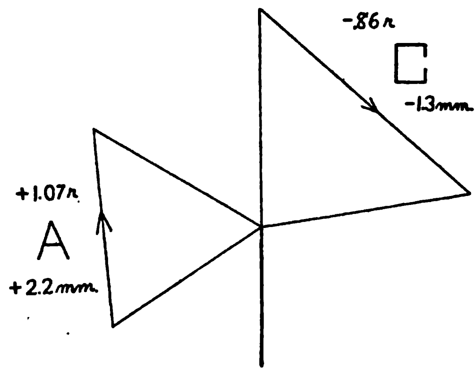


FIG. 13. (Natural size.) *Lupinus albus* (petiole in *CE*). Only two leaflets given. Original position (as shown by arrow) = average position in normal series and average length with petiole in *EA*. Final position = average position and length with petiole in *CE*. Number above leaflet letter = change of basal-terminal position. Number below = corresponding change in length.

get the difference between the "*EA*" changes in length and the changes in length in the particular group in question. These are to be compared with the basal-terminal changes of position given three spaces above them. Figs. 11, 12 and 13 give these relations in diagrammatic form respectively for Tables XX, XXI and XXII, but include only the most pronounced positive change of position and the most pronounced negative change in each case.

Table XX.

Lupinus albus. Petiole in *AB* (8 Cases). Correlation Between Change in Length and Change in Position.

	A	*B*	*C*	*D*	*E*
Av. Lg. Normal Series (16 cases).	25.5 ± .43	30.0 ± .40	31.7 ± .35	30.3 ± .45	25.6 ± .40
Av. Lg. Operated Series. Petiole in *AB* (8 cases).	22.9 ± .71	27.2 ± .40	29.2 ± .41		24.4 ± .81
Diff. = Change in Length.	− 2.6 ± 1.14	− 2.8 ± .80	− 2.5 ± .76		− 1.2 ± 1.21
Av. Position. Normal Series (16 cases) = Angle *S*.	55.9° ± 1.9°	114.7° ± 2.1°	179.7° ± 1.8°	244.1° ± 1.8°	304.6° ± 2.6°
Av. Position. Operated Series. Petiole in *AB* (8 cases) = Angle *T*.	322.1° ± 5.5°	66.1° ± 4.2°	135.7° ± 4.9°		242.5° ± 6.3°
1 − cos *S*.	+ .44 *r*	+ 1.42 *r*	+ 2.00 *r*	+ 1.44 *r*	+ .43 *r*
1 − cos *T*.	+ .21 *r*	+ .60 *r*	+ 1.72 *r*		+ 1.54 *r*
Change of Position = (1 − cos *T*) − (1 − cos *S*).	**− .23 *r***	**− .82 *r***	**− .28 *r***		**+ 1.11 *r***
Corresponding Change in Lg.	− 2.6	− 2.8	− 2.5		− 1.2
Change in Length. Petiole in *EA*.	− 1.6	− 1.8	− 2.1		− 2.2
Difference between Length Petiole in *AB* and *EA*.	**− 1.0 mm.**	**− 1.0 mm.**	**− .4 mm.**		**+ 1.0 mm.**

Measurements are in millimeters unless otherwise indicated.
r **= Length of radius.**
Lg. = Length.
Av. = Average.
Diff. = Difference.

Table XXI.

Lupinus albus. Petiole in *BC* (1 Case). Correlation Between Change in Length and Change in Position.

	A	*B*	*C*	*D*	*E*
Av. Lg. Normal Series (16 cases).	25.5 ± .43	30.0 ± .40	31.7 ± .35	30.3 ± .45	25.6 ± .40
Av. Lg. Operated Series. Petiole in *BC* (1 case).	21.3	19.7	27.0		24.9
Difference = Change in Length.	− 4.2	− 10.3	− 4.7		− .7
Av. Position. Normal Series. (16 cases) = Angle *S*.	55.9° ± 1.9°	114.7° ± 2.1°	179.7° ± 1.8°	244.1° ± 1.8°	304.6° ± 2.6°
Av. Position. Operated Series. Petiole in *BC* (1 case) = Angle *T*.	250.0°	315.0°	69.0°		207.0°
1 − cos *S*.	+ .44 *r*	+ 1.42 *r*	+ 2.00 *r*	+ 1.44 *r*	+ .43 *r*
1 − cos *T*.	+ 1.34 *r*	+ .29 *r*	+ .64 *r*		+ 1.45 *r*
Change of Position = (1 − cos *T*) − (1 − cos *S*).	+ .90 *r*	− 1.18 *r*	− 1.36 *r*		+ 1.02 *r*
Corresponding Change in Length.	− 4.2	− 10.3	− 4.7		− .7
Change in Length. Petiole in *EA*.	− 1.6	− 1.8	− 2.1		− 2.2
Difference Between Length Petiole in *BC* and *EA*.	− 2.6 mm.	− 8.5 mm.	− 2.6 mm.		+ 1.5 mm.

Measurements are in millimeters unless otherwise indicated.

r = Length of radius.

Lg. = Length.

Av. = Average.

TABLE XXII.

LUPINUS ALBUS. PETIOLE IN *CE* (11 CASES). CORRELATION BETWEEN CHANGE IN LENGTH AND CHANGE IN POSITION.

	A	*B*	*C*	*D*	*E*
Av. Lg. Normal Series (16 cases).	25.5 ± .43	30.0 ± .40	31.7 ± .35	30.3 ± .45	25.6 ± .40
Av. Lg. Operated Series. Petiole in *CE* (11 cases).	26.1 ± .81	27.9 ± .72	28.3 ± .74		24.0 ± .79
Difference = Change in Length.	+ .6 ± 1.25	− 2.1 ± 1.12	− 3.4 ± 1.09		− 1.6 ± 1.19
Av. Position. Normal Series. (16 cases) = Angle *S*.	55.9° ± 1.9°	114.7° ± 2.1°	179.7° ± 1.8°	244.1° ± 1.8°	304.6° ± 2.6°
Av. Position. Operated Series. Petiole in *CE* (11 cases) = Angle *T*.	120.5° ± 4.8°	194.2° ± 5.4°	261.7° ± 6.2°		46.3° ± 4.9°
1 − cos *S*.	+ .44 *r*	+ 1.42 *r*	+ 2.00 *r*	+ 1.44 *r*	+ .43 *r*
1 − cos *T*.	+ 1.51 *r*	+ 1.97 *r*	+ 1.14 *r*		+ .31 *r*
Change of Position = (1 − cos *T*) − (1 − cos *S*).	**+ 1.07 *r***	**+ .55 *r***	**− .86 *r***		**− .12 *r***
Corresponding Change in Length.	+ .6	− 2.1	− 3.4		− 1.6
Change in Length. Petiole in *EA*.	− 1.6	− 1.8	− 2.1		− 2.2
Difference between Length Petiole in *CE* and *EA*.	**+ 2.2 mm.**	**− .3 mm.**	**− 1.3 mm.**		**+ .6 mm.**

Measurements are in millimeters unless otherwise indicated.

r = Length of radius.

Lg. = Length.

Av. = Average.

An examination of the above tables and figures brings out the following points: If we take in each group the leaflet which has the greatest positive change of position, *i. e.*, the greatest change from a more basal to a more terminal location, and the leaflet which has the greatest opposite change, we get a very striking result. *In each case where there is a considerable rotation from a more basal to a more terminal position we get a relative increase in length and where there is an opposite rotation we get a relative decrease in length.* Using the "*EA*" length-changes as our basis of comparison we get in the "*AB*" group a change in length of + 1.0 mm. for the greatest plus change of position and of – 1.0 mm. for the greatest minus change. Likewise in the "*BC*" group we get a change of + 1.5 mm. for the greatest plus change of position and of – 2.6 mm. for the greatest minus change. In the "*CE*" group in a similar way we have a length-change of + 2.2 mm. for the greatest plus position change and of – 1.3 mm. for the greatest minus position change.

It will be noticed that some of the leaflets with a comparatively small change of position show a variation in the relation to length, but this is certainly to be expected from the nature of the experiments.

The small number of cases in each group and the consequent large probable error of the averages is more than counteracted by the great uniformity of results, and it would certainly be surprising if the latter did not indicate a true correlation.

General Remarks.

The facts brought out by the foregoing experiments seem to indicate that we have here a very fruitful and as yet practically untouched field for the study of the correlations of plant members. The interesting regulations of position and length which we have found in the leaflets of the compound leaf indicate the need of an extension of the method to leaves in other morphological relations as well as to different organs of the plant body. While correlations of size have been

studied by various workers the correlations of position are but little known. The main value of the experiments seems therefore to lie in the fact that they point to an interesting field in the study of position correlations and the relation between position and size.

The length reactions, as observed in the present case, are on the whole unexpected. The experiments on the enlargement of the stipules in many leaves after the removal of the leaf-blade,* the replacement, in *Streptocarpus*, of the large leaf-like cotyledon by the smaller one after removal of the former,† and many other cases would lead us to expect an enlargement of the remaining leaflets after the removal of one of them. Instead of this we get a very constant and almost uniform decrease in all three species. This corresponds with the results obtained by Kny ‡ in willow-cuttings (*Salix* and *Ampelopsis*) where the continued removal of the shoots retards the growth of the roots and vice versa. F. Hering § found a similar retardation in the growth of one member of a seedling when the other was imbedded in gypsum. Experiments by Kny and Hering in which either the root or the shoot of a seedling was removed, however, showed no effect upon the growth of the other part, except that Hering found a retardation for a short period after the operation. The brief decline Townsend ‖ has pointed out is probably due to the effect of the injury stimulus and Kny has further suggested that the later apparent independence of growth may be due to the accelerating influence of the regenerating shoot on the root or of the root on the shoot.

The reactions in the present experiments were entirely free from any factor due to the stimulus of a regenerating

* Goebel, K. Organographie der Pflanzen, 180. 1898.

† Hering, F. (Über Wachstumscorrelationen in Folge mechanischer Hemmung des Wachsens.) Jahrb. Wiss. Bot. 29: 142. 1896.

‡ Kny, L. On correlation in the growth of roots and shoots. Ann. Bot. 8: 265. 1894; Second paper. Ann. Bot. 15: 613. 1901.

§ Hering, *l. c.* 139.

‖ Townsend, C. O. The correlation of growth under the influence of injuries. Ann. Bot. 11: 509. 1897.

member and it is highly improbable that the injury stimulus played a considerable part because of the comparatively small injury, the rapid healing of the cut surface, and the long period of growth undisturbed by any further injury. With the exception of Pfeffer's restriction of growth method as used by Hering, the present method seems to excel the others in all three of the above points. In the case where the growth is restricted by imbedding in gypsum it is not improbable that the constant stimulus of the contact more than counterbalances the advantages of the method, and as Kny has pointed out the disturbance in nutrition must be a serious factor.*

The interesting correlation between position and length as made out in *Lupinus albus* naturally brings up the various theories of the relation between the position of a leaflet in the leaf-system and its size. There are so many facts in other cases which go to disprove any connection between the directness of the path of nutrition and the size of a leaf that we are not justified in concluding that the first necessarily determines the second. In the present state of our knowledge it is perhaps safest not to rush too hastily into obviously mechanical explanations of the facts of regulation.

The results obtained in the position regulations have so few other facts to serve for comparison that it is hard to get their bearings on general questions of morphology and physiology. The most superficial glance at the results is sufficient to show that the reactions cannot be explained on any obviously mechanical basis. Nor can we explain them as direct results of the stimulus of the injury produced at the moment of the leaflet removal. They seem to be bound up with the internal correlations within the leaf-system itself and independent of any external factors. One very evident fact stands out

* Four months after my results were presented before the Botanical Society of America, Professor Němec gave a paper dealing with the results of a similar investigation by himself in which he also found that the imbedding of leaflets in gypsum was so faulty by reason of the pathological conditions induced that it could not be used to advantage. [Němec, B. Ueber die Folgen einer Symmetriestörung bei zusammengesetzten Blättern. (Presented Nov. 14, 1902.) Bull. Internat. Acad. Sci., Bohême, 1902.]

through all the results, and that is *that the regulatory changes following the operation are in the direction one would expect them to take in forming a new symmetrical system based on one less than the usual number of leaflets.* The importance of the petiole position as the center around which the readjustment takes place is evident in all cases. At first sight one might be inclined to attribute this predominance entirely to the coarse obviously mechanical stresses exerted by the petiole. The reactions in *Lupinus albus*, however, cannot be explained in such a way. One can very well imagine the complexity of the internal factors controlling the configuration of the leaf system in this case when the removal of the leaflet causes such an intricate reaction in a leaf where, on account of the rigidity, we should expect very little internal rearrangement. Yet even here we find the very complexity a valuable aid in determining the component parts of the reaction and the results lead us to hope that we may in the future be able to get at some of the laws of the correlation. For instance, the possibility of obtaining the value of the petiole factor in so far as it influences the size of the leaflet interval is certainly of general interest. May we not in a similar manner in other organs obtain the relative values of the members in determining the configuration?

Summary of Method and Results.

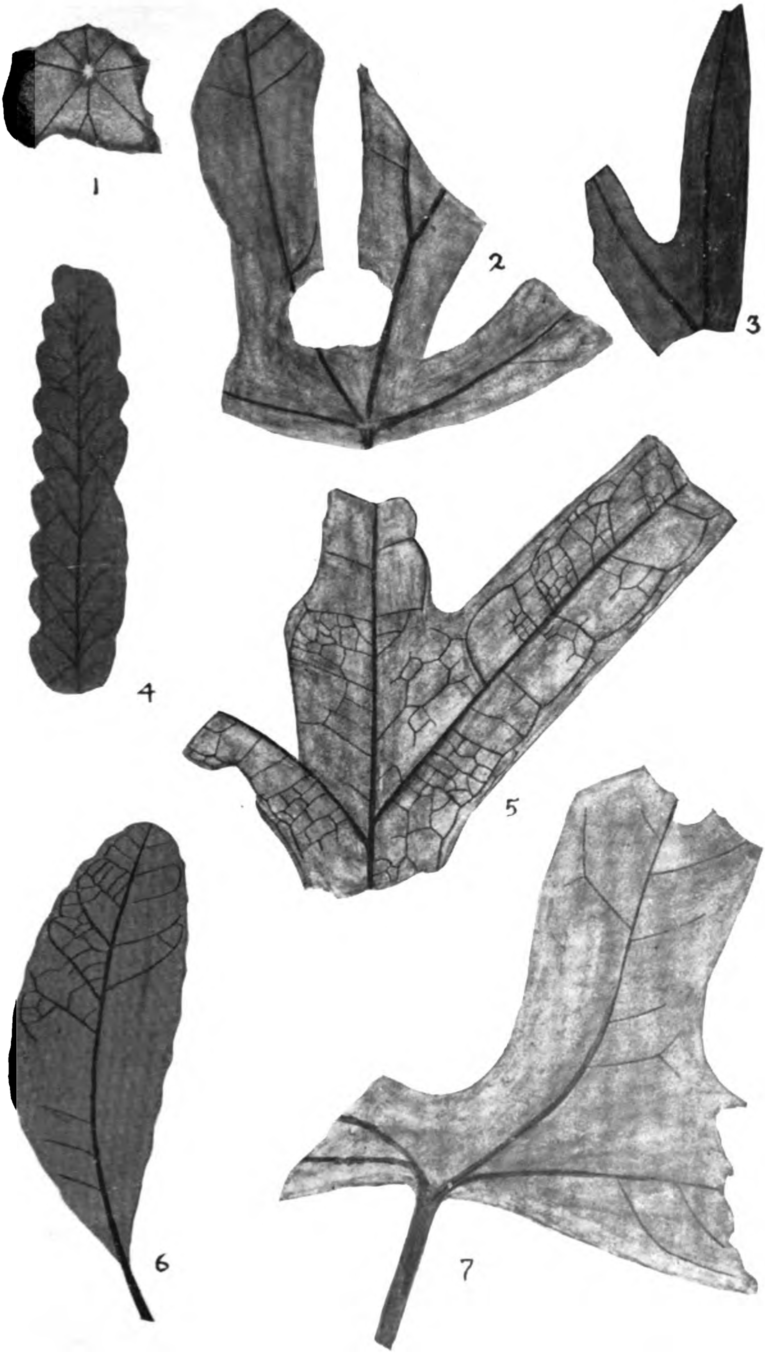
Two coördinate series of leaves were taken in each of three species of plants (*Parthenocissus quinquefolia*, *Trifolium pratense* and *Lupinus albus*) and were kept under conditions as nearly alike as possible except that in one of the series a particular leaflet, the one at the immediate right of the terminal one, was removed at the earliest possible stage. When the leaves had attained their maximum size, measurements of the length and angular position of the leaflets in both series were taken on the same day. A comparison of the average lengths and average positions of the leaflets in the two cases gave the change produced as the result of the operation. The changes were treated under three heads, changes of position, of intervals and of length.

The changes of position were principally confined to the two leaflets left in an asymmetrical position with respect to the petiole as a result of the operation and were apparently directed toward the closing up of the enlarged interval left by the removed leaflet. In *Lupinus albus*, in a large number of cases, a considerable plus or minus rotation of the whole leaf-system was induced which cannot be explained according to the above reactions. In these rotations one or more of the leaflets were carried across the surface of the petiole.

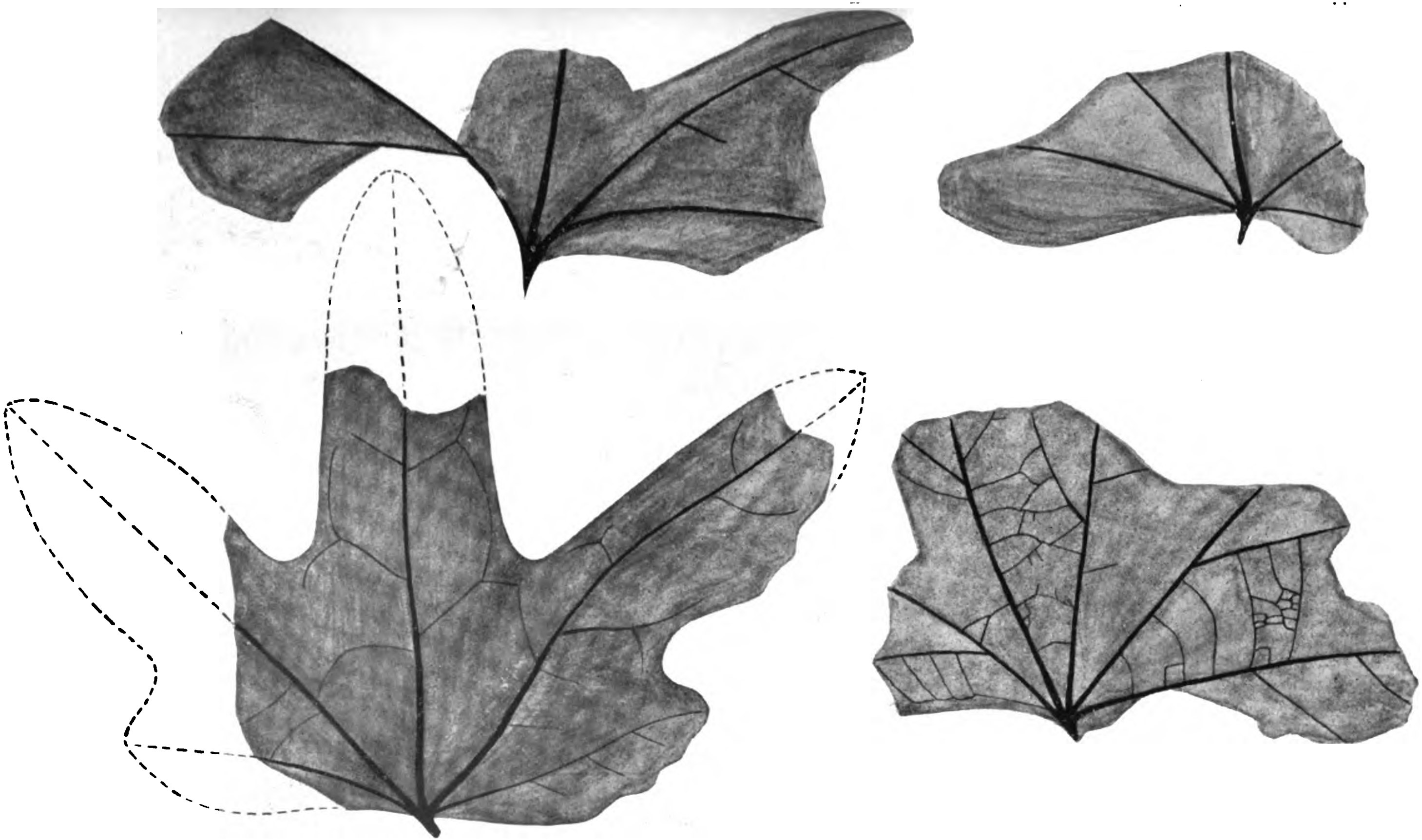
A consideration of the values of the intervals in the operated series as compared with the normal series gave the manner in which the closing up of the enlarged interval was accompanied by increase in the other intervals. It was found that in *Lupinus albus* the main increase was confined to the asymmetrical intervals and was nearly equally distributed between them. In *Parthenocissus quinquefolia* a slight plus movement of the leaflet at the left of the basal interval and a minus movement of the one at the right prevented a similar result. From the extensive and varied rotations of *Lupinus albus* it was possible to calculate the effect of the petiole upon the value of an interval. The average value of this petiole factor was found to be $+ 37°$.

A consideration of the length of the leaflets in the operated series as compared with the normal series showed that there was a very uniform decrease in size of the remaining leaflets as a result of the removal. The average decrease for the three species amounted to 6.8 per cent. of the normal length.

In the case of *Lupinus albus* a study of the correlation between length of leaflets and their position in the leaf-system brought out the fact that a change from a more basal to a more terminal position was accompanied by a relative increase in length as compared with the cases in which the opposite rotation took place.



NELUMBO, ARALIA, STERCULIA, MORICONIA, CELASTROPHYLLUM.



ARALIA PALMATA Newb.

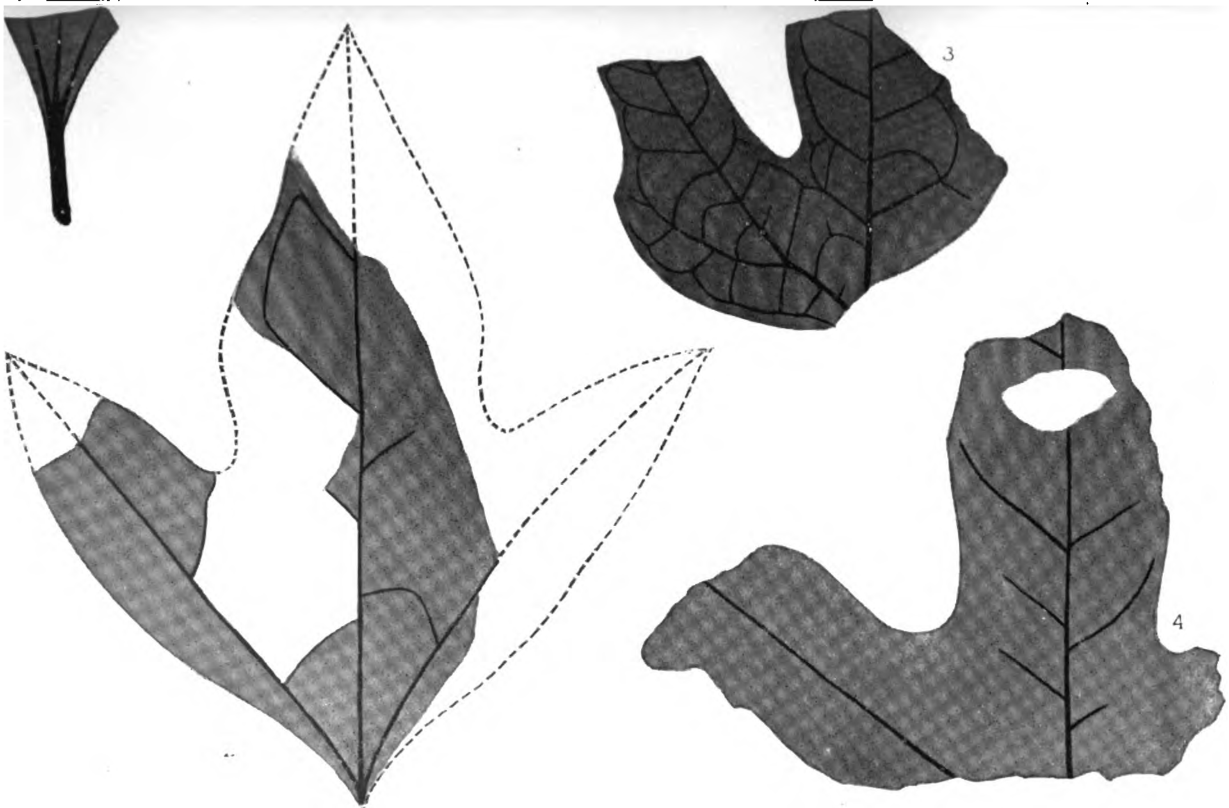
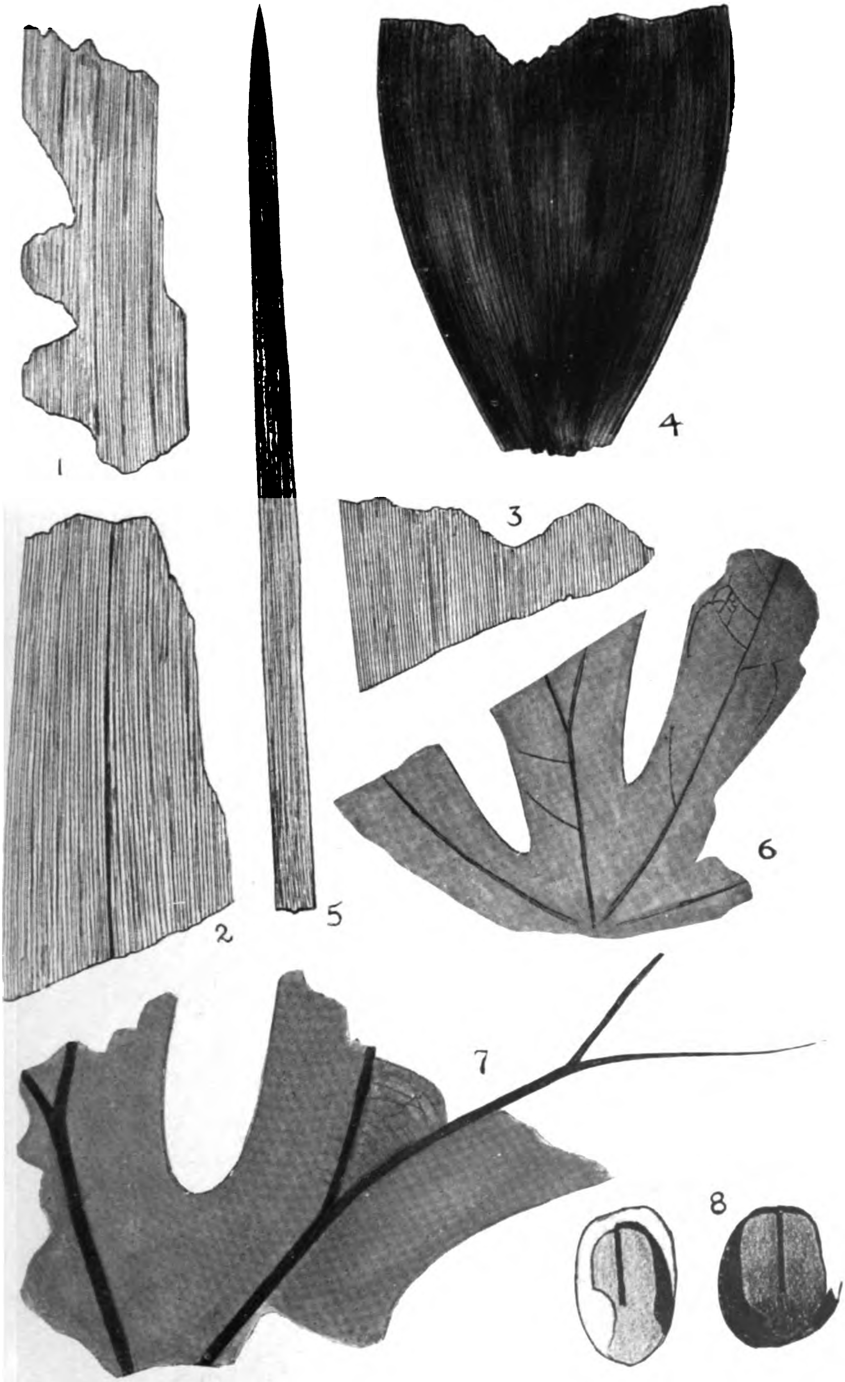
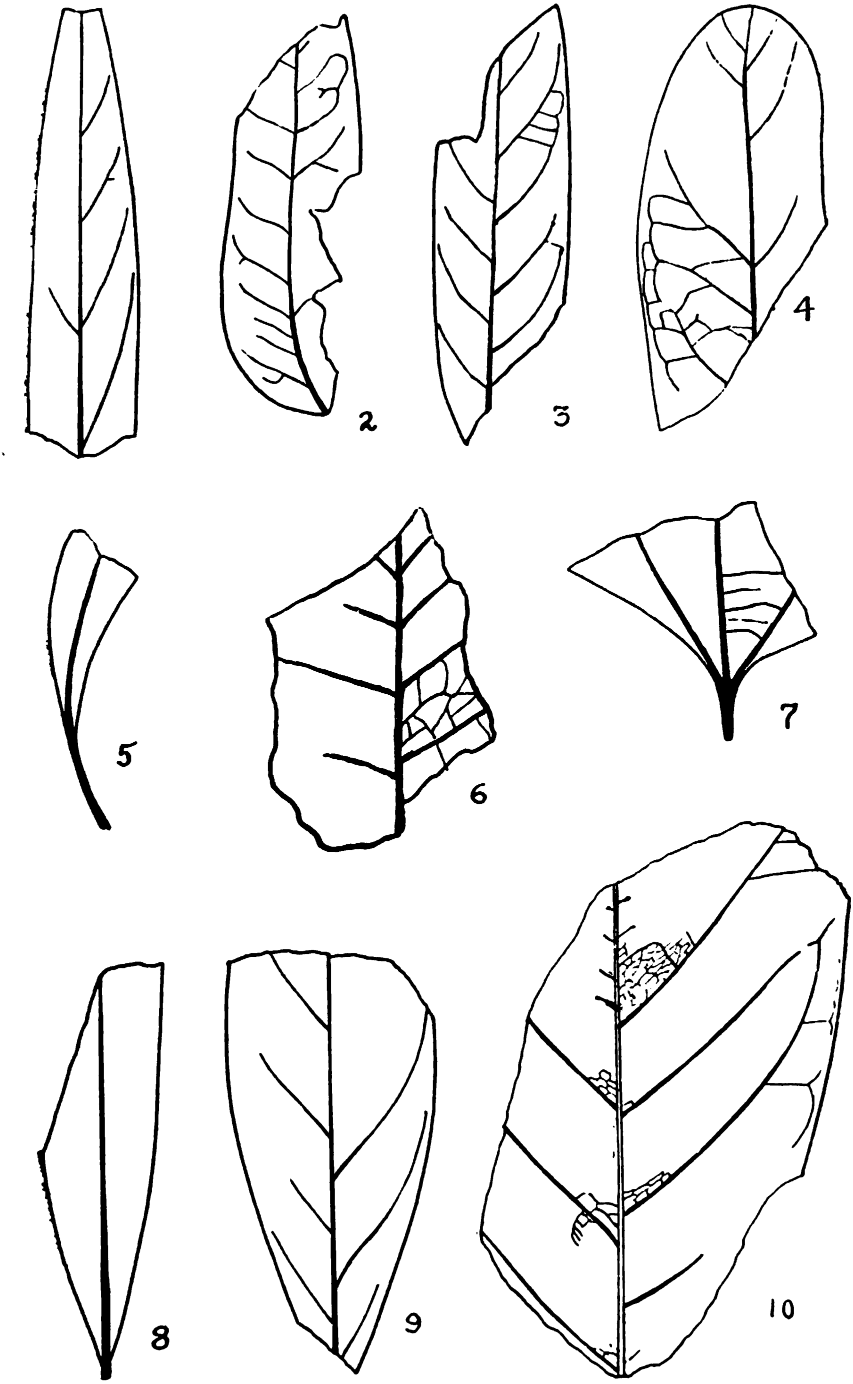


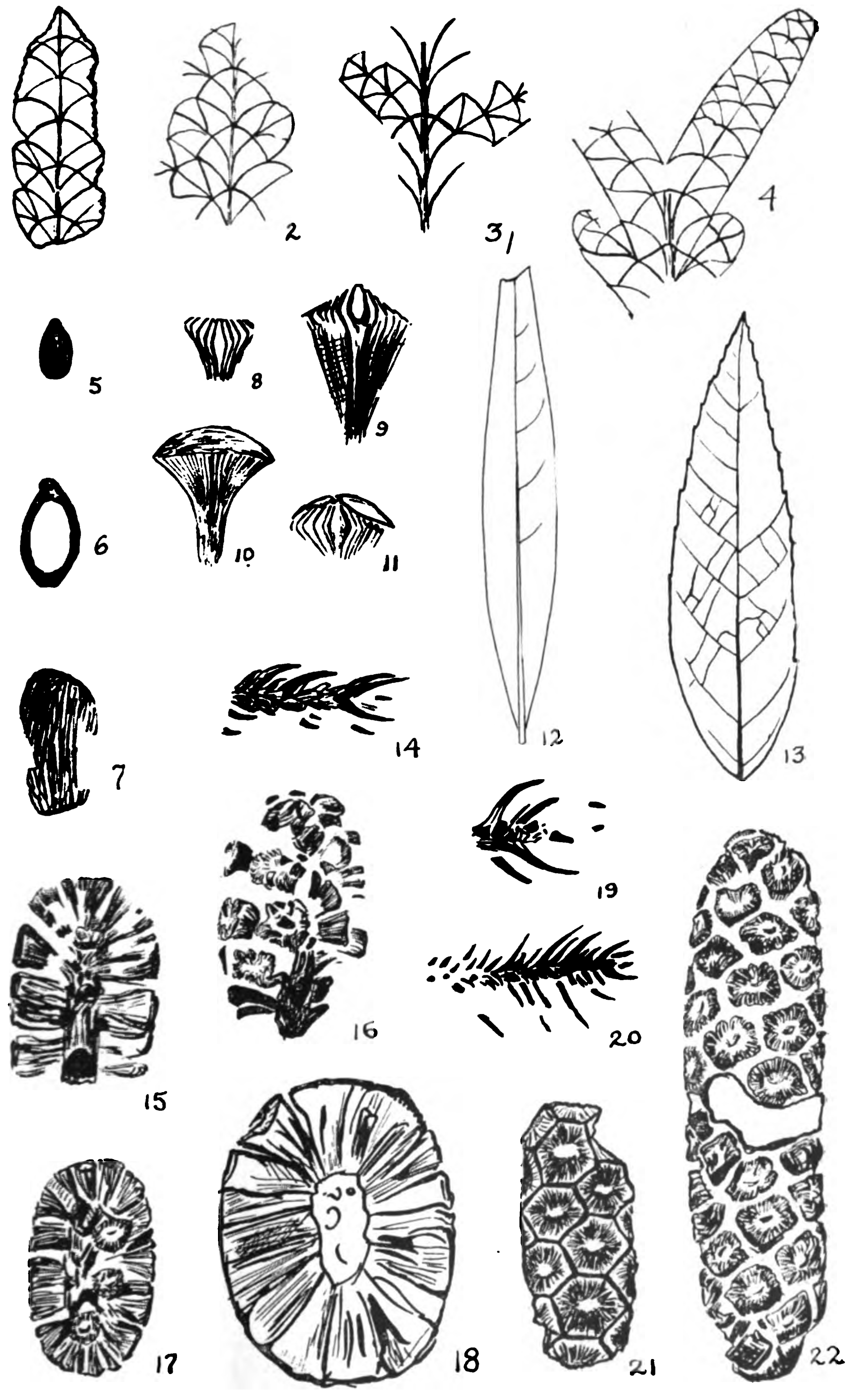
FIG. 1, 2. SASSAFRAS ACUTILOBUM Lesq. FIG. 3. ARALIA BRITTONIANA Berry.
FIG. 4. ARALIA GROENLANDICA Heer.



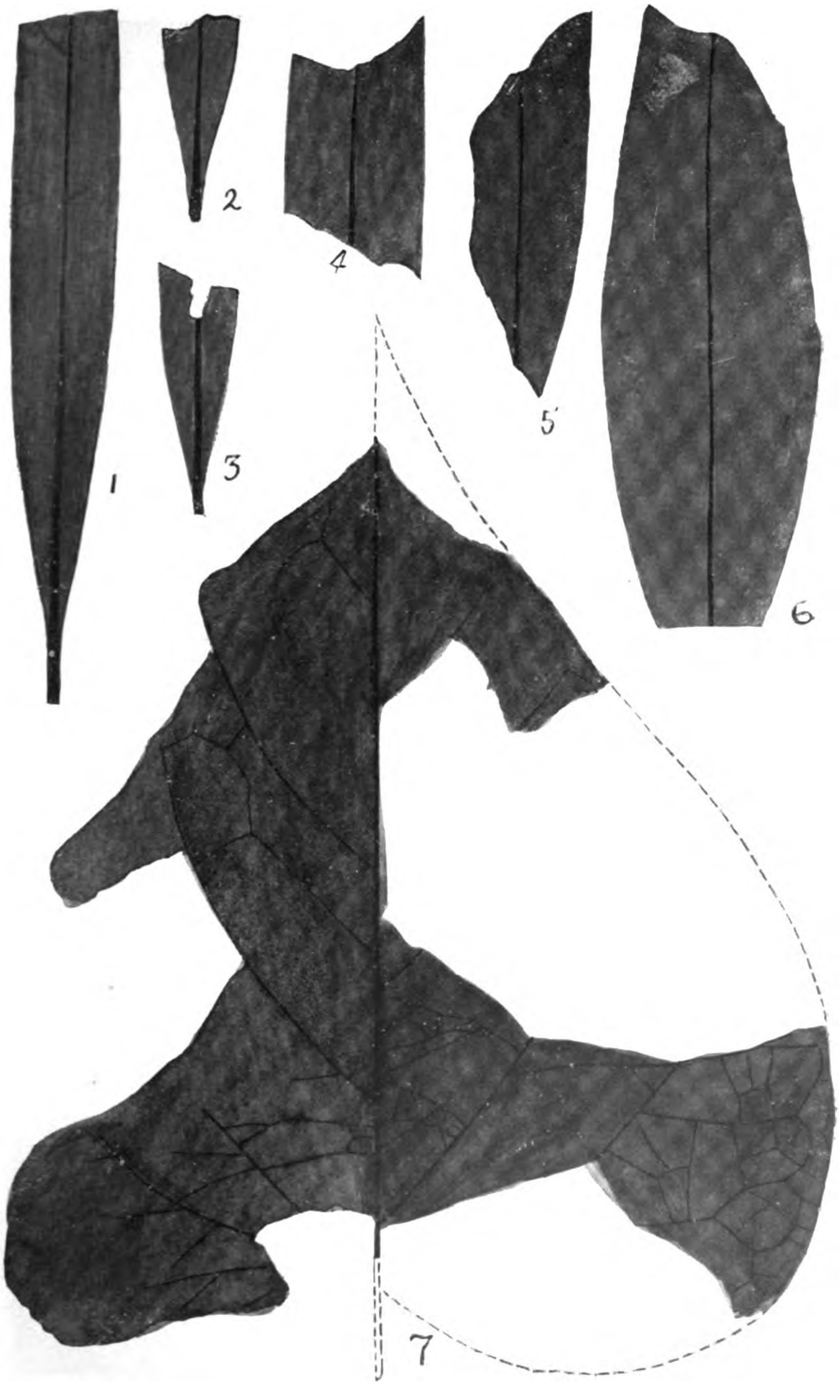
PODOZAMITES, ARISAEMA,
PHRAGMITES (?), ARALIA, CARPOLITHUS.



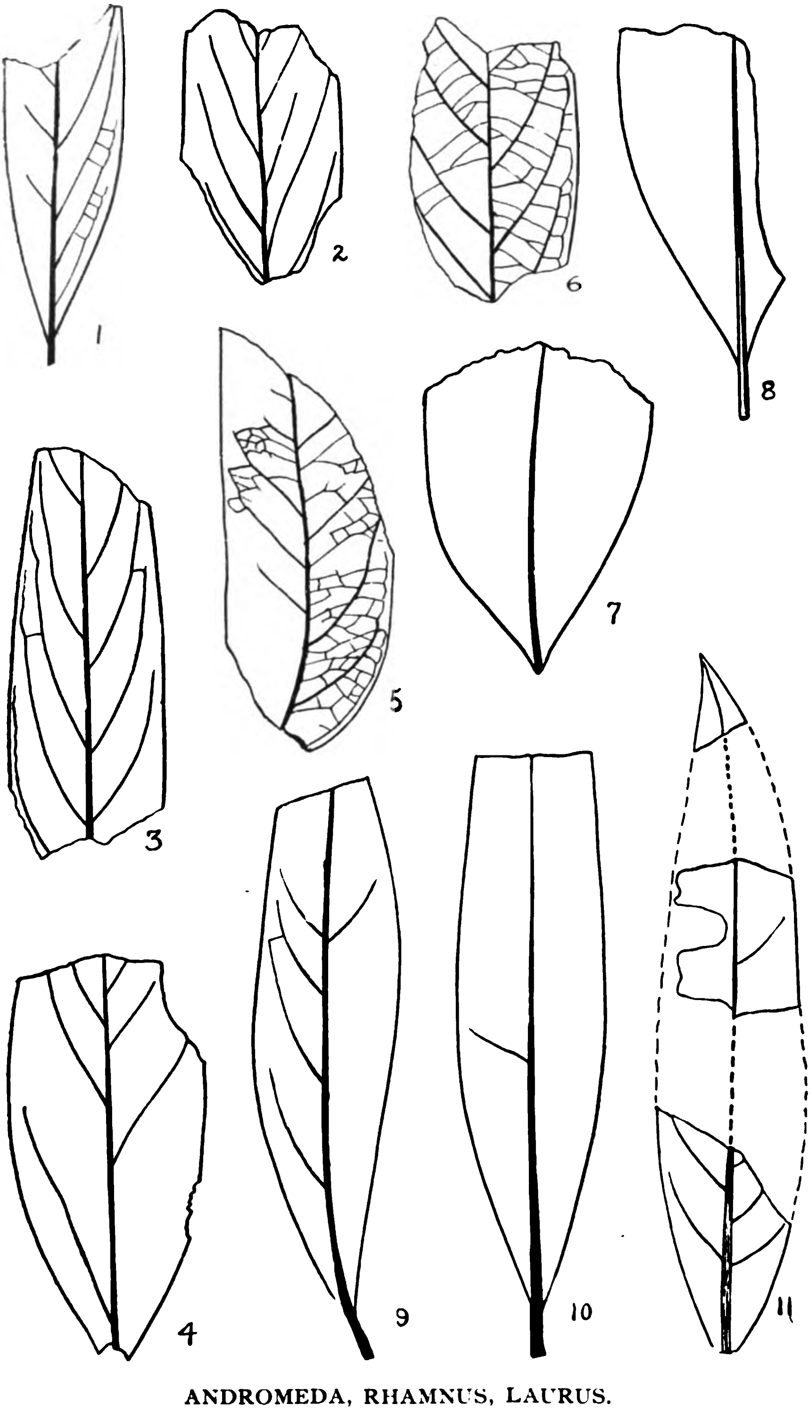
LAUROPHYLLUM, SAPINDUS, MAGNOLIA,
QUERCUS, FICUS, LAURUS.



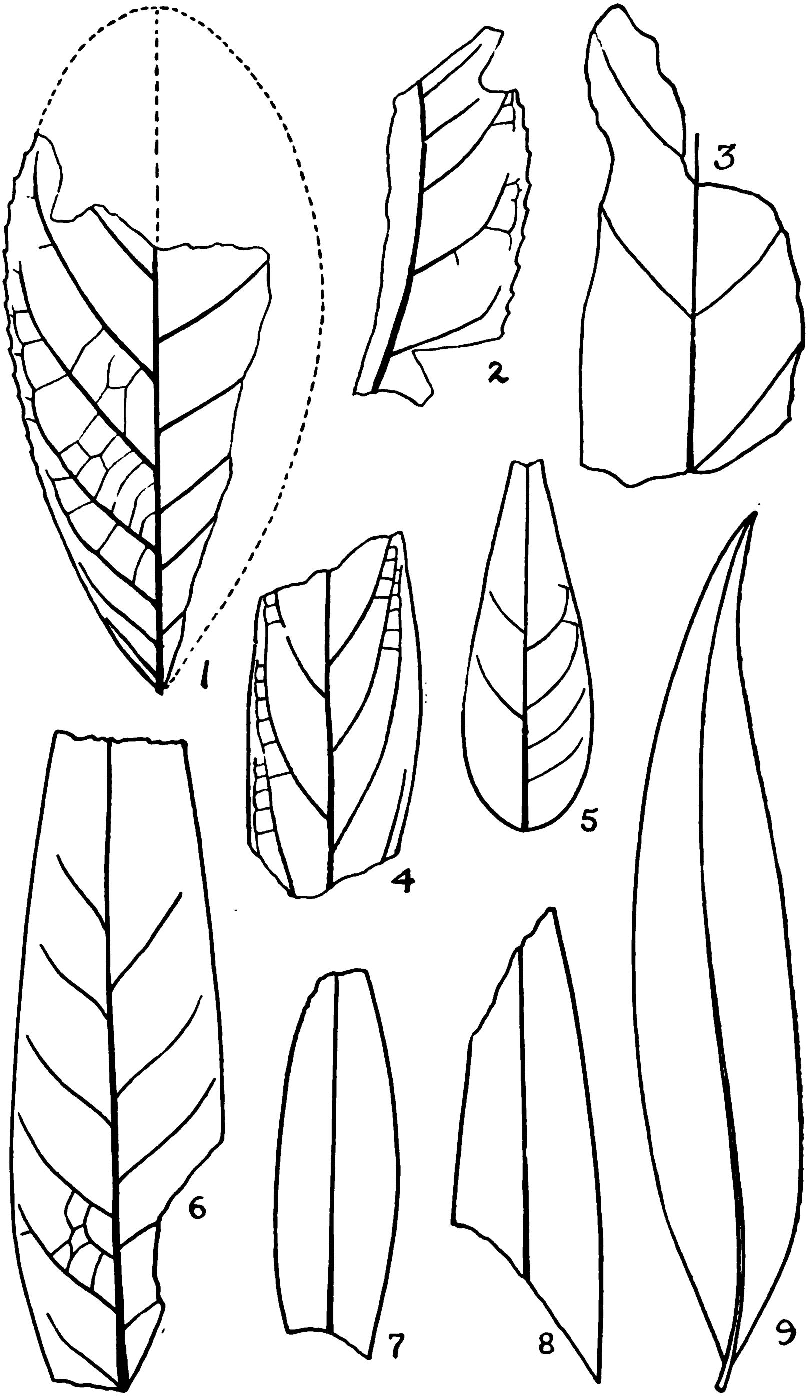
MORICONIA, CARPOLITHUS, DAMMARA, SALIX, QUERCUS, CUNNINGHAMITES, SEQUOIA.



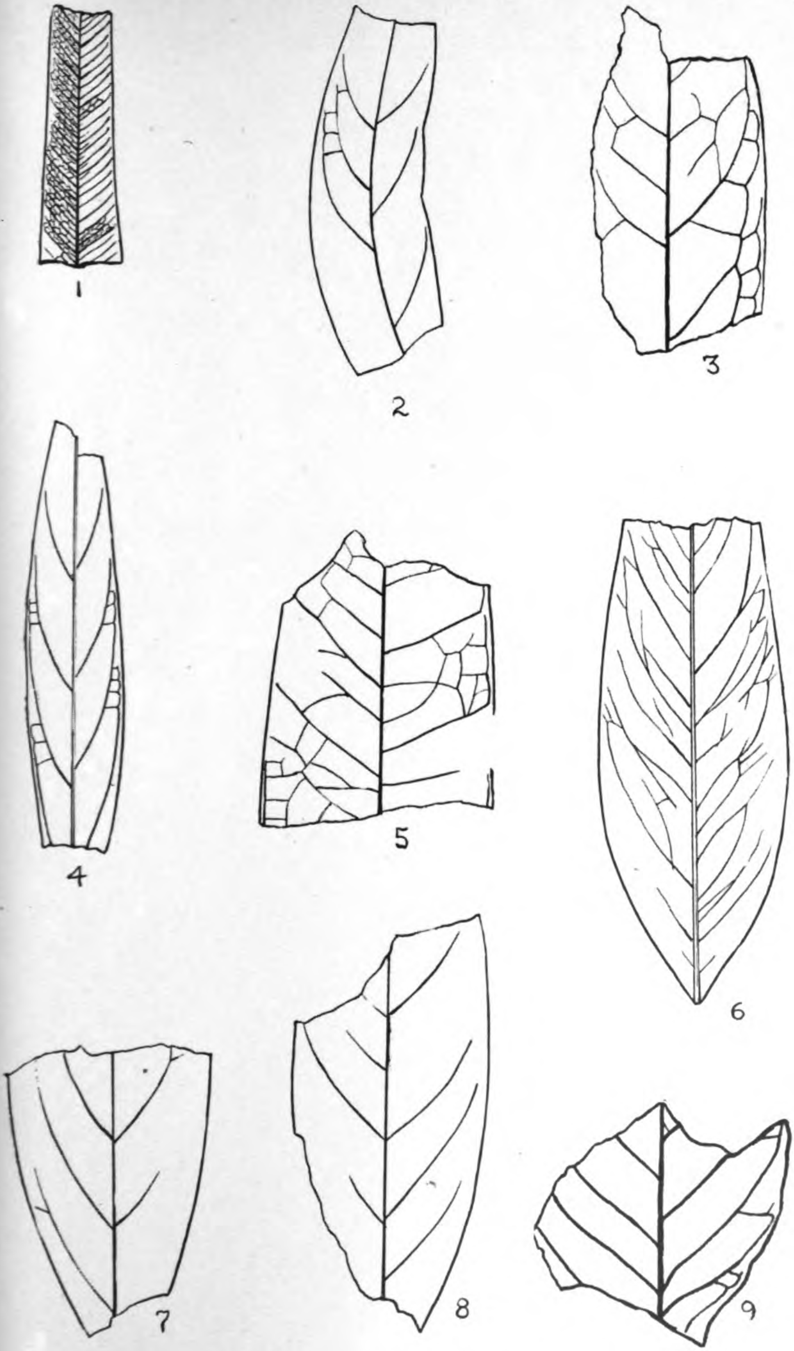
LAUROPHYLLUM, LAURUS, POPULITES.



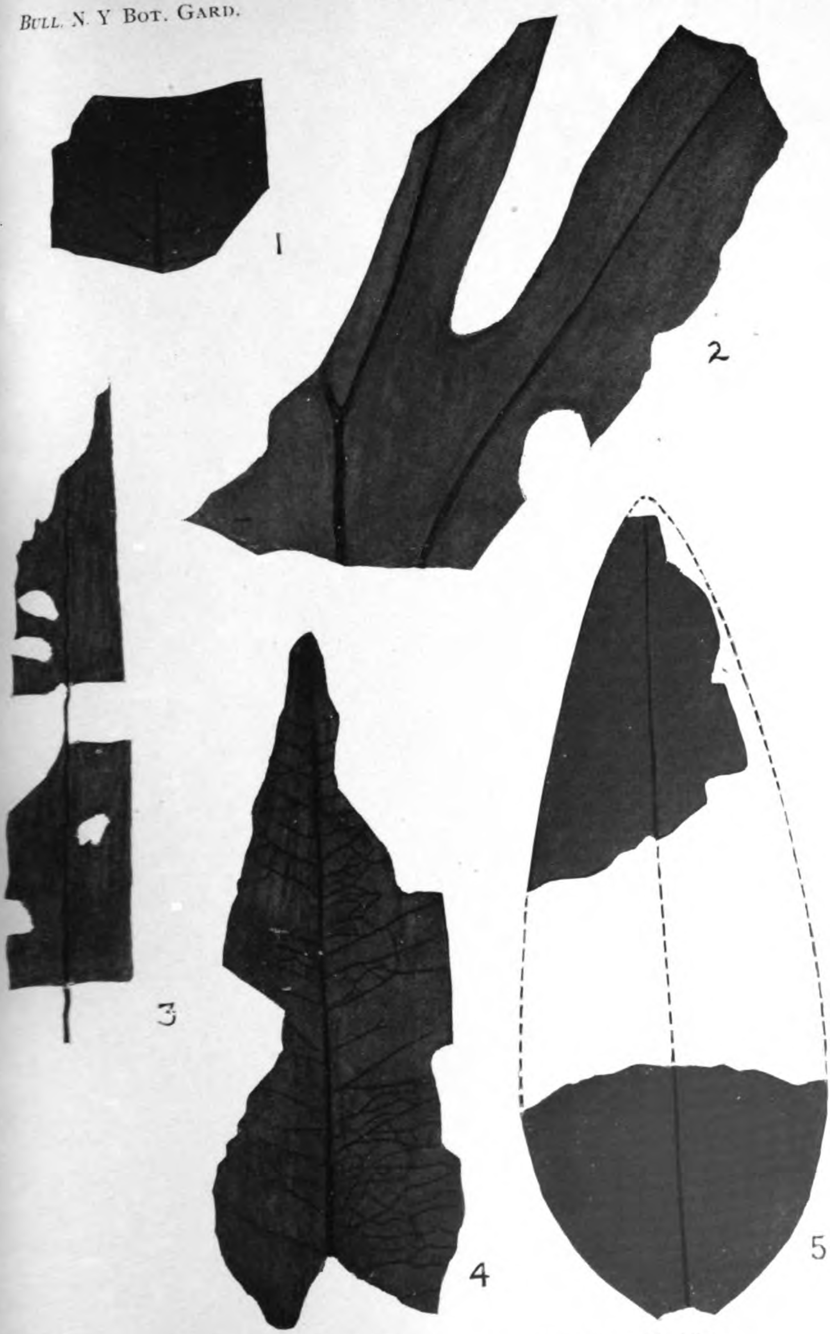
ANDROMEDA, RHAMNUS, LAURUS.



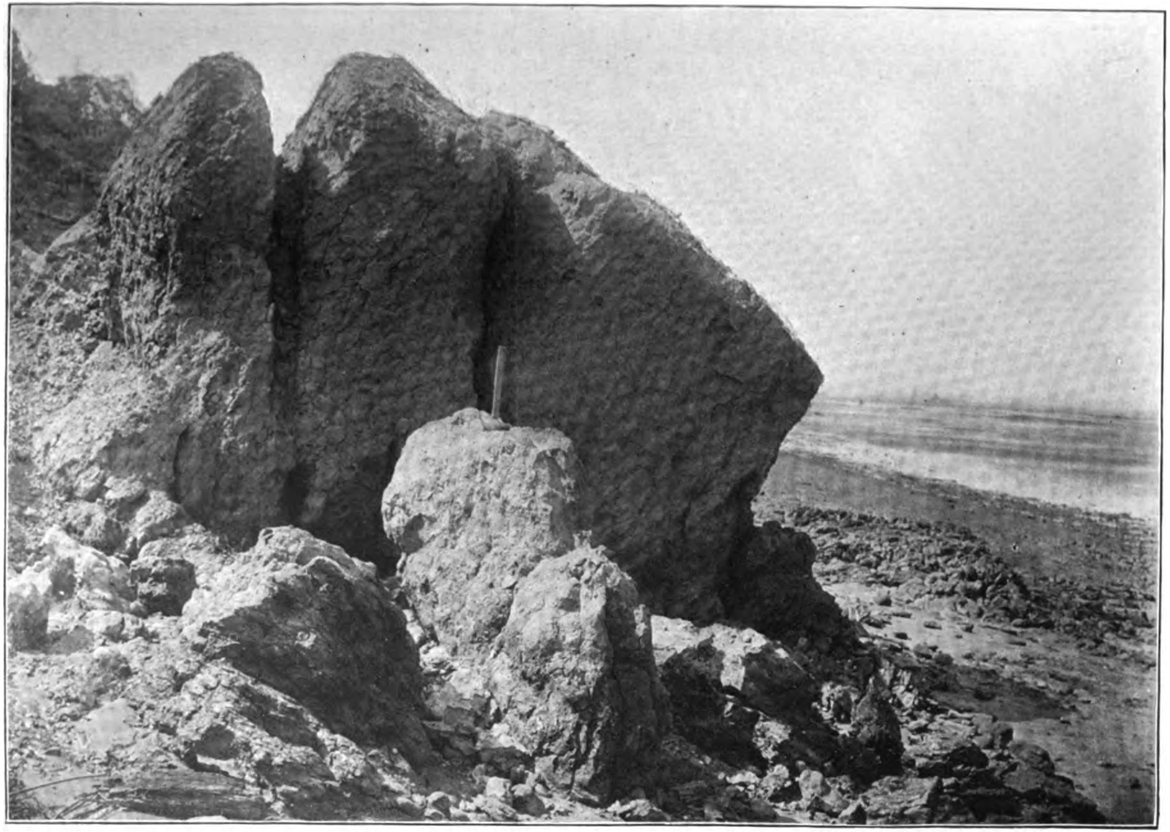
QUERCUS, SALIX, PROTEOIDES.



EUCALYPTUS, SALIX, FICUS,
MYRSINE, LAURUS, QUERCUS.

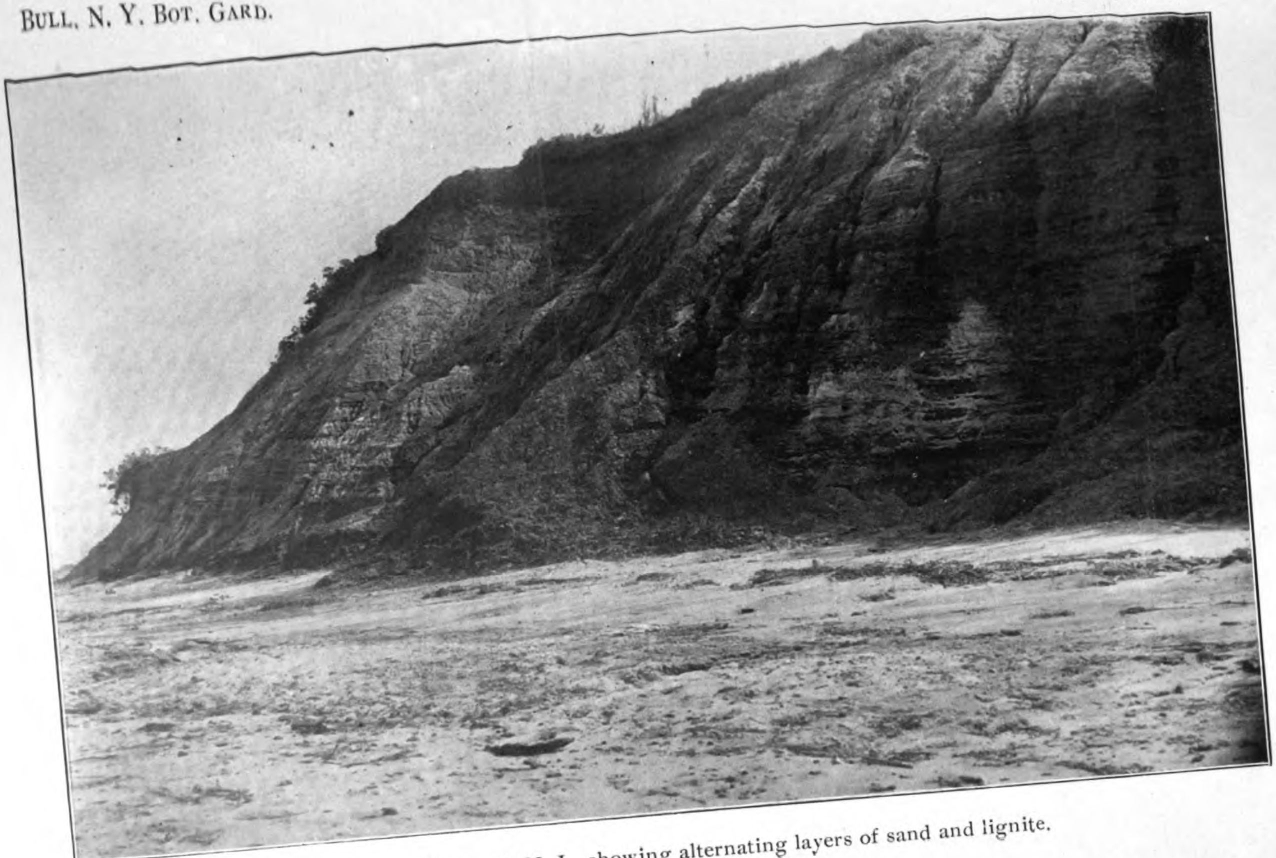


FICUS, ARALIA, EUCALYPTUS, MAGNOLIA.

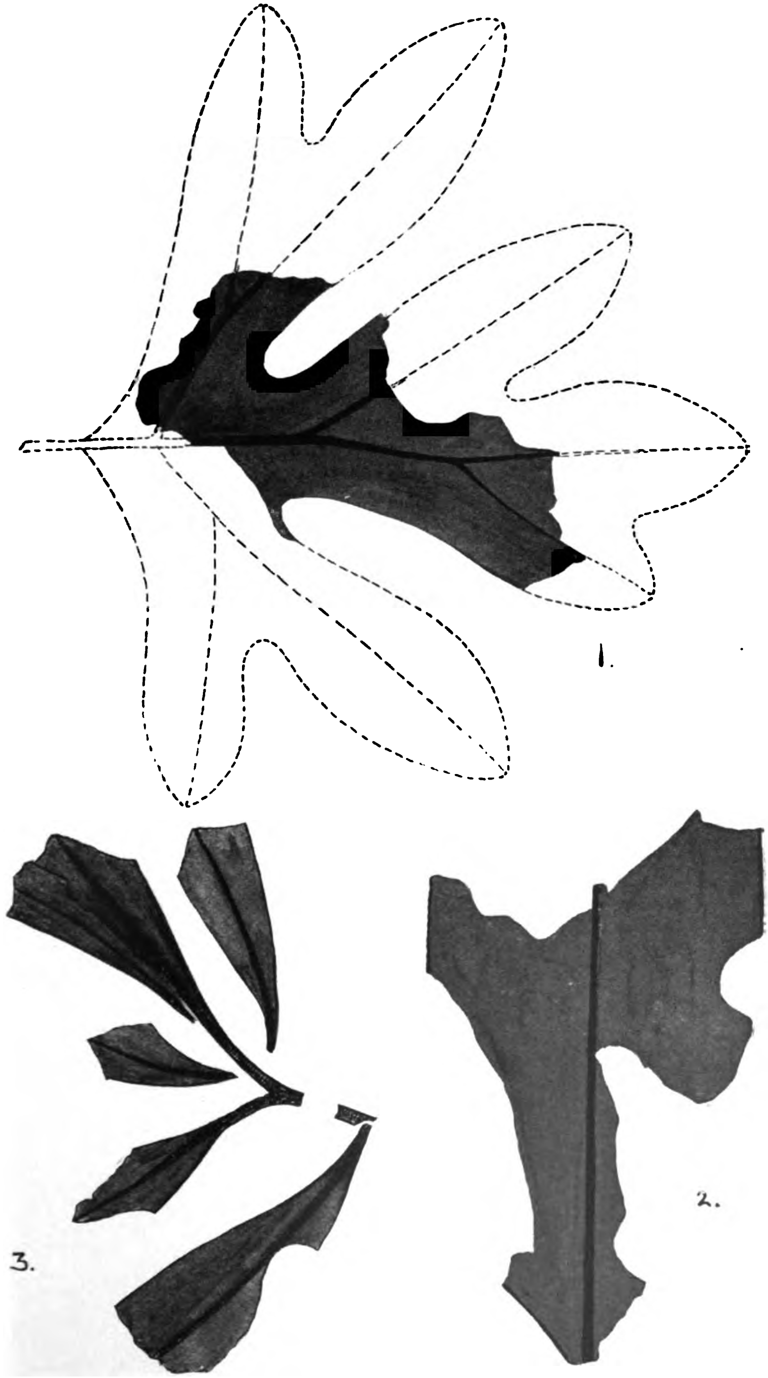


Boulders of clay, yielding plant remains, on beach near Cliffwood, N. J.

Bluff near Cliffwood, N. J., showing how its face is obscured by landslips.



Bluff near Cliffwood, N. J., showing alternating layers of sand and lignite.



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BULLETIN

OF

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[ISSUED MARCH 22, 1904]

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BULLETIN

OF

The New York Botanical Garden

Vol. 3. No. 10.

REPORT OF THE SECRETARY AND DIRECTOR-IN-CHIEF FOR THE YEAR 1903.

(*Received and ordered printed January 11, 1904.*)

To the Board of Managers of the New York Botanical Garden.

Gentlemen: I have the honor to submit herewith my report as Secretary and Director-in-Chief for the year ending January 11, 1904.

The year has witnessed continuous development in all the departments of the Garden. Construction-work has been actively pushed, the collections have been largely increased, and their efficiency for teaching purposes has been bettered by considerable rearrangement and more complete labeling; the number of visitors has been greater than that of any previous year, and we have had more students and visiting investigators than ever before. The permanent funds of the Garden have been increased by about $5,000; the number of annual members and life members now stands 1,094, an increase during the year of 45. A large number of gifts both of money and of books and specimens have enabled us to supply much needed scientific material without expenditure from our ordinary income.

Roads and Paths.

The contract of the Department of Parks with John B. Devlin, awarded December 11, 1900, was finally completed in the summer, after long delay, and accepted by the Depart-

ment of Parks. On account of the delay the Commissioner of Parks imposed a very large time-penalty on the contractor. The work under this contract completed nearly all the paths and driveways planned about the public conservatories, and a large amount of the rough grading made necessary by the location of the building.

The driveway extending from the herbaceous garden southward through the woods, and through Bronx Park along the west side of the river to Pelham Avenue, was completed and thrown open for driving early in the spring. It has proved to be a most useful road and the woodland scenery traversed is very attractive.

During the year a path about 1,800 feet long and 15 feet in width was built from the approach to the Manhattan Elevated Railway station southeasterly parallel with and a few feet from the rough stone wall on the line of the property of St. John's College to the southern entrance at the Southern Boulevard. This path follows the natural grade for most of its length, except at its southeastern end where considerable grading was necessary, including the removal of a portion of a ledge of rock about eight feet thick, and the building of a culvert to take care of the drainage. The construction of this path was made necessary by the enormous number of visitors reaching the Garden by means of the Elevated Railway.

The grade of the driveway between the garden fountain and the drinking fountain at the south end of the approach to the museum building, was raised during the spring for a distance of about 300 feet in order to conform to the grades necessitated by the completion of these two fountains and the driveway portions of this approach, the new road being laid directly upon the old.

Paths connecting the path approaches to the public conservatories with the southern entrance at the Southern Boulevard, and this entrance with the herbaceous garden path-system and with that leading to the museum building, in all amounting to about 2,000 feet, averaging 12 feet in width,

have been completed during the year, and the path-system of the herbaceous grounds has been connected with a path leading southward through Bronx Park to Pelham Avenue, constructed by the Department of Parks.

The paths on the terrace of the public conservatories were completed according to plan except at the points where steps will lead to the lower level, and around the sites of the tanks for aquatic plants.

A path ten feet in width and about 500 feet long has been built from the West 200th Street entrance at the bridge over the New York and Harlem Railway to the approach to the elevated railway station.

All these paths have been built in the most substantial manner with a Telford foundation eight or nine inches thick carefully laid, hammered and rolled, and surfaced with about two inches of trap rock screenings.

The path planned to parallel the driveway on the easterly side of the museum building, northward toward the fruticetum, has been partially graded for about 400 feet, and stone assembled along it for the Telford foundation.

Partly under the direction of the Garden and partly under that of the Commissioner of Parks, the driveway-system north and east of the museum building, on both sides of the Bronx River, has been partially constructed, and this work is still in progress; it is expected that it will be completed, together with a portion of the accompanying path-system during 1904. The work has been prosecuted at a number of different points, in accordance with the general plan for the development of the Garden, the grading being nearly all done and about one half of the Telford foundation being laid up. When completed this driveway-system will connect with the Mosholu Parkway to the west, with Newall Avenue, leading north, and with Bleecker Street leading to the White Plains road on the east.

Bridges.

Plans for the single-arched concrete, steel and stone bridge to carry the main driveway over the Bronx River at the

northern end of the Garden were approved early in the year, and the contract for the execution of the work was awarded by the Commissioner of Parks to Mr. Frederic Koopman; construction was begun in May and has since continued. This bridge is now very nearly completed, only some details of finish being needed.

Work on the bridge which is to carry the driveway and path-system of the Mosholu Parkway into the Garden over the right-of-way of the New York Central and Hudson River Railroad Company, at a point opposite the west end of the museum building, was commenced in the autumn under a contract of the Department of Parks, and the construction of the abutment on the west side of the railroad is going forward, but work has not yet been commenced upon the abutment on the Garden side of the railroad. Space in the planted border along the railroad for this abutment was made early in the fall by moving the trees and shrubs which would come in the way of construction operations. Considerable work has also been done upon the driveway approaches to this bridge and upon their connection with parts of the road-system already built.

Plans for the five-arched rubble stone bridge to carry the main driveway across the Bronx River and its valley, at a point about 500 feet north of the present "Blue Bridge," were approved late in the year; and a contract was awarded by the Commissioners of Parks to Mr. F. Leahy for the sum of $69,000. The work may be completed in about a year.

Plans for the bridge to carry the driveway over the valley of the two lakes northeast of the museum building have been prepared, but an additional appropriation will be necessary to carry them into effect.

The wooden "Blue Bridge" across the river at the northern end of the hemlock forest has been kept in repair by the Commissioner of Parks.

Grading.

The grading about the public conservatories left unfinished after the completion of the contract with John B. Devlin,

before referred to, has been continued and is now essentially completed with the exception of topsoiling a considerable area on the hillsides east and northeast of that building, and a small area near the southern entrance at the Southern Boulevard. In order to get sufficient depth of loam and topsoil for future planting, over the numerous rock ledges, and to effect the most economical distribution of the surplus rock and poor soil to points where it was needed for filling and for the construction of roads and paths, it has been necessary to prosecute this work slowly and with great care. It is proposed to finish the topsoiling of the areas still denuded as rapidly as possible in the spring, using for this purpose soil stripped from the locations of additional paths and driveways, which sources have hitherto supplied all the topsoil that has been used in the development of the general plan of the Garden.

The surplus stone obtained from the grading of the rough rocky hill which formerly stood in front of the east wing of the museum building, which had been piled by the contractor on the field in front of that building and between it and the public conservatories, was all broken up during the early part of the year and transported to the driveways under construction north of the museum building, where it was laid up for Telford foundation. The area which it occupied, together with the area in front of the east wing of the museum building left unfinished at the end of 1902, was regulated, graded, topsoiled and sown, and thus brought into lawn by early summer.

The area from the power house to the approach to the elevated railway station was similarly regulated, graded and sown. Numerous small areas between driveways and paths have also been regulated, graded and sown during the year.

In these grading operations a total of about ten acres has been added to the finished lawn surfaces, and including the plain set aside for the collection of shrubs northeast of the museum building, where road and path building is still going

on, a total of about fifteen acres more is so far advanced toward completion that it is expected that it will be brought into a finished condition during 1904.

It still remains to remove the surplus rock from the excavations just north of the public conservatories which was piled by the contractor on an adjacent hillside, and to grade the rocky hill on which this pile rests, this work being the heaviest single piece of grading work that is still needed to complete the carrying out of the plan in the area south of the museum building; much of this rock will be used however in the construction of the five-arched stone bridge across the valley of the Bronx River before alluded to.

The grading operations in connection with the building of driveways in the northern part of the Garden have already been described under the heading of Roads and Paths.

In the rear of the museum building work has been going on at times during the year in removing the surplus rock and earth necessary to form the court of the building in accordance with the general plan, and is still being prosecuted, the stone being distributed along the lines of paths still to be built, taking advantage of the frozen condition of the ground during winter for this heavy cartage, while the soil is being carted to points where additional filling is needed in grading and in the building of driveways. This work may profitably go on all winter.

Drainage and Sewerage.

At the commencement of the year work was being prosecuted on the connection of the sewer and drainage system of the southwestern portion of the Garden with the Webster Avenue sewer, the line passing under the New York Central and Hudson River Railroad right-of-way under the approach at West 200th Street. The work was completed early in the spring, all necessary catch-basins and manholes constructed, and a rather difficult piece of work successfully accomplished.

In completing the grading operations and paths in the vicinity of the public conservatories and along the driveway near the museum building, ten additional catch-basins were

built and connected with the main drains, necessitating the laying of about 400 feet of six-inch and eight-inch pipe.

In order to drain the court at the rear of the museum building, and to improve the drainage of the building itself, work is at present going forward in laying a drain about 450 feet long, to be connected with the upper lake, and this may be completed during the winter.

At the southern end of the herbaceous garden, the brook and drainage system was connected with the large stone drain built by the Department of Parks, at the time the path connections were made at that point with the path running south through Bronx Park to Pelham Avenue, and an open ditch which had long been a mosquito-breeding spot was entirely eliminated.

A mosquito-breeding swamp on the west side of the Bronx River north of the "Blue Bridge" has been turned into a small pond by raising the height of its bank along the Bronx River and by the cutting out of surplus trees and undergrowth; this adds about a quarter of an acre to the water surface in the Garden and eliminates an unsightly marsh.

Work has been begun on a sewer connection, about 500 feet in length, to complete the sewerage system planned for the area east of the Bronx River.

The southern portion of the glade north of the herbaceous garden which was taken up this year for plantations illustrating structural botany, has been drained and graded; the brook which runs through the herbaceous garden has been extended about 300 feet northward, taking advantage of the natural watershed, and greatly improving this area of about one acre.

Water Supply.

The only extension of the water supply made during the year was the laying of one-inch pipe northward from the northern end of the herbaceous garden through the area just referred to, a distance of about 350 feet, and the bringing of water to the public comfort station, now under construction, at the approach to the elevated railway station.

Buildings.

1. *Museum.* The care of the museum building has mainly been restricted to ordinary repairs, and the structure is in good order. The contract of the Department of Parks with Thomas Dwyer for the building and placing of a large amount of additional furniture was satisfactorily completed early in the spring. Additional construction-work includes the building of two sinks, one on each of the main museum floors, enclosed in closets for the janitors; these greatly facilitate the cleaning of the building. Additional sinks were also placed in the laboratories on the upper floor, their need having been demonstrated. An accidental explosion of dynamite used for blasting rock shattered many panes of glass at the east end of the building on December 18; the damage was at once repaired.

Front Approach to the Museum Building. The contract of the Department of Parks with the Wilson & Baillie Manufacturing Company, for the construction of the front approach to the museum building, was finally completed and the work accepted early in the year.

A design for the fountain planned for construction at the end of this approach and immediately in front of the museum building has been approved by the Board of Managers, on the recommendation of a committee selected by the National Sculpture Society, and has also been approved by the Commissioner of Parks. Considerable time will be required in preparing the models, and in casting the bronze for this fountain, but it is hoped that it will be in position by the autumn of 1904.

2. *Public Conservatories.* No additional construction-work has been done at these great glass houses, and they have been kept in good order with ordinary repairs, including the painting of the entire exterior.

During the autumn a contract was awarded by the Commissioner of Parks to Guidone and Galanti for the construction of two concrete steel tanks in the court of the public conservatories for the growing of tender and half-hardy

water plants, one of them to be provided with a heating system connected with that of the conservatories; this contract also includes the construction of two large and four small flights of cut stone steps at the edge of the terrace on which the conservatories stand, and will essentially complete all construction-work contemplated at the public conservatories, in accordance with the general plan of the Garden. The amount of this contract is $16,598.

3. *Power House and Subways.* These, and the steam heating plant in general have required only ordinary repairs, and are in good order at the present time, the only incident in operation worthy of special remark having been a leak in the steam main to the museum building at a point about midway between that building and the power house, which was discovered and repaired late in the autumn.

4. *Propagating Houses.* Only ordinary repairs have been necessary at the propagating houses. The increase in the number of plants to take care of has crowded them inconveniently at times, but this will be relieved by the execution of a contract for the building of an additional propagating house, awarded by the Commissioner of Parks to Hitchings & Co. in the autumn, the amount of this contract being $7,593. This work will complete the range of propagating houses in accordance with the general plan of the Garden and will also supply a number of propagating pits, which have been much needed. Slight repairs to the present propagating houses will be included in this work.

5. *Stable.* Only ordinary repairs have been needed to keep the stable in good order.

6. *Public Comfort Station.* This building was built at the time the museum building and the power house were constructed and it was included in the general contract for buildings. Inasmuch as path approaches to it had never been completed, and it was located north of the museum building near the upper lake, at a place little frequented by visitors, it has never been opened for use by visitors and was kept securely locked and frequently inspected. It was tempora-

rily used for the storage of a barrel of alcohol. On July 17 two museum aids went to this building for the purpose of drawing a can of alcohol from the barrel; through their carelessness and disobedience of instructions they set fire to the building, which was so badly damaged in consequence that it was found necessary to tear it down.

Plans for two public comfort stations to be built at the approach to the elevated railroad station have been prepared by Mr. R. W. Gibson, architect, and the plans approved. A contract for the building of these structures was awarded by the Commissioner of Parks to Springsted & Adamson for the sum of $12,873. The plans contemplate the heating of these stations by a steam main from the power house.

7. *Tool House.* No changes have been made at this building.

8. *Approach to the Bronx Park Station of the Manhattan Railway Company.* No changes have been made in this structure and it is in good repair.

Care of the Grounds.

The general maintenance and watering of the roads and paths already constructed has been done by employees of the Department of Parks, two men having been detailed for this purpose, one on each side of the Bronx River. The increased area of finished roads and paths west of the Bronx River will necessitate the work of another man during the next season.

The drainage has been carefully inspected and the catch-basins cleaned out whenever necessary. Slight temporary flooding has taken place at two or three points during very violent storms, but on the whole the drainage system has worked admirably, and has been much improved by the construction of some additional catch-basins.

The finished lawns and banks have been mowed and rolled at frequent intervals, and kept in as good order as the means at command have permitted. The great increase in finished lawns and banks will require the work of more men for this purpose during the coming season.

The hay on all the undeveloped parts of the tract was cut during the summer and stacked in barracks near the stable, sufficient being obtained in this way for fodder for the Garden horses. This quantity will become less from year to year, as the area of finished lawns increases. The woodlands have been carefully patrolled during dry weather, as a precaution against forest fires. A few trees have died and been taken down, and a considerable number were blown over during two violent gales. Unsightly and partly diseased trees, and those which were crowding and therefore spoiling better specimens, have been removed, over parts of the area, and considerable pruning has been accomplished.

The police patrol has been somewhat increased during the year, but it has been found necessary to supplement this on Sundays and holidays, and at times during the afternoons, by guards selected from our own employees. This has prevented any serious damage being done to the plantations or woodlands by visitors, in spite of the greatly increased number of persons coming to the Garden, but it will evidently soon be necessary to station a permanent guard at at least three of the entrances.

The scattering of rubbish by visitors has apparently not been much further reduced than it was last year, and it has been found necessary to detail a man for most of his time during the summer and autumn to clean up the litter. Perhaps the only way to entirely stop this nuisance would be to prevent visitors bringing parcels of any kind within the grounds, as is done at many European parks and gardens, and was resorted to during the last year by the Commissioner of Parks of Brooklyn, but in the absence of a wall or fence around the Garden, and in the present impossibility of maintaining guards at all the entrances, we are not yet in a position to enforce such restriction.

Considerable complaint has been made by visitors of their annoyance by the drivers of cabs and hacks soliciting patronage at the entrances and at other points on the driveways. Several arrests for this offence were made by the

police, but when brought before the city magistrates it was discovered that, while forbidden by rules of the Deparment of Parks, no penalty had apparently been fixed for such misdemeanors, and the prisoners were discharged. In reply to an inquiry by the Commissioner of Parks, the Corporation Counsel confirmed, as his opinion, this condition, and suggested that the attention of the Mayor's Marshal, who controls the licenses of public conveyances, be brought to this nuisance, and this has been done, but as yet without appreciable diminution of the annoyances.

Plants and Planting.

1. *Herbaceous Grounds.* This tract has been kept under high cultivation, and the specimens as fully labeled as our available force would permit. Considerable additions have been made to the individual beds from specimens brought from the nurseries and received from various other sources, while some species cultivated last year have not been carried through for one reason or another. The number of kinds of plants grown here during the year is about three thousand.

During the autumn an extension of this system of beds was made to the northward, across the driveway and paths leading to the hemlock forest, for the purpose of establishing the series of plantations to teach structural botany, and twelve additional beds were laid out and stocked with specimens for this purpose. This ground was graded, so as to slope to the central stream, and may be brought to a finished condition early in the spring.

2. *Fruticetum.* The construction of roads and paths through the tract devoted to the exhibition of shrubs occupying the plain northeast of the museum building has not yet been completed, though work upon it is in an advanced state, and these operations have delayed the finishing of the surfaces and have consequently deferred the permanent planting of a considerable part of the collection. The collection was entirely replanted and moved in the spring, much of it into permanent position, and the work here is likely to be

essentially completed during 1904. Considerable additions have been made to this collection of shrubs from various sources, so that now about 665 species are available for study.

3. *Salicetum.* The area of marsh and meadow land at the northern end of the Garden devoted to the collections of willows, poplars and other water-loving trees and shrubs is in much the same condition as the fruticetum, owing to the building of roads and paths, and the collections here have not been materially increased, the number of species cultivated being about 30. Here also much finished work may be accomplished during 1904.

4. *Arboretum.* Early in the spring a large collection of hardy conifers, presented to the Garden by Mr. Lowell M. Palmer of Stamford, Connecticut, was set out in the area between the museum building, the herbaceous garden and the approach to the elevated railroad station in accordance with the general plan, thus commencing the installation of the evergreen part of the tree plantations, which will be referred to as the pinetum. Some additions were made to this collection in the autumn, and it will be increased from time to time as the desired trees are obtained.

Additions have also been made to the collection of deciduous leaved trees in the aboretum tract east of the Bronx River. In all the number of kinds of hardy trees now represented in the Garden, including some still in the nurseries and yet too small to be set out, is about 450.

5. *Viticetum.* The collection of vines planted on the rough arbor built some years ago near the edge of the forest east of the museum building, has been cultivated but not increased.

6. *Public Conservatory Collection.* The collections of plants in the great glass houses have made much growth during the year, and have been increased from a variety of sources, principally from specimens obtained by gift, and by others collected during the several expeditions sent out by the Garden into tropical America; also by plants derived from seeds and cuttings grown in the propagating houses. The number of species now exhibited in the public conservatories is about 6,600 as against 5,800 a year ago.

7. *Nurseries.* It was found necessary during the year to take about half an acre of additional land into cultivation at the nurseries on the east side of the Garden in order to provide space for the plants grown there. During both spring and fall and at intervals during the summer, plants have been transplated from the nurseries to the herbaceous garden, to the fruticetum and to other plantations.

8. *Boundary Borders.* The planted borders have been kept cultivated, and treated to a considerable extent as nurseries; many shrubs and trees have been moved from them during the spring and fall into other places. During the fall, after the completion of the long path leading from the elevated railroad station approach to the southern entrance at the Southern Boulevard, the border of trees and shrubs along this line was wholly replanted for about one half its length; the other half may be taken up in the spring; about 1,000 shrubs were required to do this planting.

9. *Other Plantations.* During the autumn, trees were set out along the entire system of finished driveways between the museum building, the approach to the elevated railroad station, and the southern entrance at the Southern Boulevard, about forty different species being used in this planting, with the desire of shading the driveways and paths as soon as possible. Considerable planting was done in the spring about the entrance at the elevated railroad station, and the existing miscellaneous shrub plantations have been kept under high cultivation.

The total number of kinds of plants represented in all the plantations and conservatories, including the native flora of the Garden, is about 11,600, which is a gain during the year of about 1,000 species.

A contribution of $200 by Mr. Samuel N. Hoyt was used for the purchase of plants.

Library.

As stated by the Librarian, whose report is hereto appended, there has been an increase of 1,656 bound volumes during

the year, the total number of bound volumes on the shelves being now about 14,600; of this addition, 493 volumes were presented; these gifts have been duly published in the JOURNAL under the head of accessions. Contributions of money used for the purchase of books and credited to the Special Book Fund have been made as follows:

Andrew Carnegie (special contribution)	$1,997.88
Samuel N. Hoyt	100.00
John I. Kane..	100.00
Miss Violetta S. White..	100.00
John S. Kennedy..	100.00
Joseph Stickney..	100.00
James B. Ford..	100.00
Miss Elizabeth Billings..	75.00
Chas. F. Cox	50.00
Samuel P. Avery	50.00
Richard H. Allen..	25.00
Joseph Bushnell..	25.00
F. W. Devoe..	25.00
E. S. Harkness..	25.00
Hugh J. Chisholm..	25.00
Jno. E. Parsons	25.00
Mason A. Stone..	25.00
A. F. Estabrook	25.00
Robert F. Ballantine..	25.00
Miss E. V. C. Morris..	25.00
Mrs. D. C. Blair	25.00
Geo. C. Thomas	25.00
Bernard G. Amend	25.00
T. G. Sellew..	25.00
Edwin D. Trowbridge..	25.00
Thomas Dwyer..	20.00
W. B. Dickerman	20.00
Henry Iden, Jr..	20.00
Peter Marié..	10.00
George Blumenthal..	10.00
Louis Haupt..	10.00
Matthew B. DuBois..	10.00

Paul N. Spofford	10.00
Miss Caroline C. Haynes	10.00
H. W. Cannon	10.00
Thomas Thacher	10.00
A. S. Frissell	10.00
John H. Rhoades	10.00
Miss Anna Riker Spring	5.00
	$1,315.00

The special contribution made by Mr. Carnegie was for the purpose of enabling the Garden to obtain a selection of books from the library of the late Professor Jordan, sold at auction in Paris, France, early in May; about 340 rare and important works were thus secured.

A considerable number of additional exchanges for our publications have been arranged, particularly with foreign institutions, so that the number of institutions on our exchange list at present is 305, as against 257 during the previous year.

The additional furniture which was supplied under the contract of the Commissioner of Parks with Thomas Dwyer, completed in the spring, has afforded space for all the additional volumes; it is evident, however, that additional shelving will soon again be needed to take up the growth of the library.

Museums and Herbarium.

As shown by the report of Curator, hereto appended, about 85,000 specimens have been added to the collections contained in the museum building, and about 45,000 specimens have been incorporated and labeled, leaving about 40,000 specimens which we have not been able to install, but which are still in the store-rooms; on account of lack of funds, we have been unable to take care of the material this year as rapidly as it has been obtained, but I hope that a better record may be made during 1904.

The additional furniture put in last winter and spring necessitated an entire rearrangement of all the collections, and this required much time and attention by the curators and their aids.

The labeling of the collections installed for public observation and study has gone forward as rapidly as possible, and a large number of the cases are now practically completely equipped with labels. Specimens have been added so rapidly however, that we have not been able to quite keep the labeling up to date.

It is proposed during the next year to give especial attention to the cases designed to illustrate North American dendrology, located in the east wing on the main floor of the building; many specimens have been assembled for this exhibit, which is planned to illustrate the trees of the United States and British America north of Mexico and the Caribbean Sea by selected specimens of wood, bark, twigs and fruits, and by plates and photographs.

Contributions of money for the purchase of collections credited to the Museum and Herbarium Fund, have been made as follows during the year:

D. O. Mills	$ 400.00
Samuel N. Hoyt	100.00
Addison Brown	100.00
Edward D. Adams	100.00
Mortimer L. Schiff	100.00
Miss Phebe Anna Thorne	100.00
Wm. R. Sands	50.00
Miss Ellen J. Stone	50.00
Bradley Martin	50.00
Mrs. Wm. Bryce	50.00
Morris K. Jesup	50.00
Wm. Stewart Tod	25.00
Wm. A. DuBois	25.00
Miss Katharine DuBois	25.00
Mrs. Geo. W. Collard	25.00
Miss Caroline Phelps Stokes	25.00
Miss Olivia Phelps Stokes	25.00
Zenas Crane	25.00
Andrew Fletcher	15.00
Theodore Cooper	10.00
Francis Lynde Stetson	10.00

Jacob Mahler......	10.00
Mrs. N. E. Baylies...	10.00
Edward G. Burgess...	10.00
Mrs. Wm. Combe...	10.00
Mrs. John A. Morris...	5.00
	$1,405.00

When the additional furniture was built, in the spring, it was determined to distribute the herbarium into three rooms of the upper floor of the building, instead of keeping it all in the large room in the east wing, which it was rapidly outgrowing. Herbarium cases for the algæ were therefore placed in the room just west of the library, and others for the fungi, ferns and fern-allies, in the morphological laboratory between the library and main herbarium room, while the mosses were placed in cases in a small room between the morphological laboratory and the main herbarium room. Eight cases for holding collections of specimens under study were placed in the room just east of the library. The result of this rearrangement and expansion has been to restrict the main herbarium room at the east end of the floor to the collections of flowering plants.

Up to this autumn the work of the curators in caring for the collections has been assisted only by museum aids. As the collections have increased the need of a more responsible person to take charge of the physical condition of the collections and of the building itself, has been demonstrated, and this was met in November, under the authority of the Scientific Directors, by the appointment of Mr. J. A. Shafer, for some years custodian of the botanical collections in the Carnegie museum at Pittsburgh, Pa., as custodian of the museums of the Garden, his salary being arranged for by reducing the number of museum aids previously employed.

Laboratories.

The report of the Director of the Laboratories hereto appended shows that 46 students, including graduates of 40 different colleges and universities have been granted the

privileges of the laboratories, library, and herbarium, during the year, and that investigations covering a wide range of subjects have been prosecuted by them. Visiting investigators from other institutions have also been given facilities in the laboratories.

In this department, as in others, the additional furniture completed during the spring has rendered work and study much more convenient and effective.

Lectures.

As in previous years courses of public lectures have been delivered on Saturday afternoons in the spring and fall in the lecture-hall of the museum building. These have been duly announced by card to the members of the Garden and by publication of their titles in the JOURNAL and other periodicals. The notices to members have included, as before, invitations to inspect various departments of the Garden in advance of the lectures on Saturday afternoon under the guidance of members of the staff, and these invitations have been taken advantage of by many members.

Exploration.

The work of obtaining plants and specimens for the collections from various parts of the world has been continued during the year as funds for this purpose became available, several members of the staff participating in this work. The most valuable of all scientific material brought into the collections is obtained only in this way, and much of the success in establishing the collections has been due to our ability to conduct explorations. During the year this work has been accomplished by means of appropriations from our general fund, and by the following contributions of money credited to our special exploration fund:

William E. Dodge	$ 600.00
Jacob H. Schiff	250.00
Geo. W. Perkins	250.00
Geo. S. Bowdoin	100.00
Edward Cooper	50.00

Roland G. Mitchell	50.00
Wm. H. Macy, Jr.	25.00
Frank R. Chambers	25.00
James Loeb	25.00
Miss Mary T. Bryce	25.00
Newbold Edgar	25.00
N. L. Britton	25.00
Mrs. Esther Herrman	10.00
Emil Wolff	10.00
Wm. B. Osgood Field	10.00
Samuel P. Avery, Jr.	10.00
H. Knapp	10.00
Edmund S. F. Arnold	10.00
C. A. Coffin	10.00
Augustus St. Gaudens	10.00
H. Victor Newcomb	10.00
Henry Holt	10.00
Mrs. Edwin Parsons	10.00
Mrs. Emerson Opdycke	5.00
	$1,565.00

Mr. F. S. Earle spent the month of March in the mountainous region of eastern Cuba, in company with Professor Underwood; Mr. E. W. D. Holway was also in the party. The especial object of the expedition was an investigation by Professor Earle, of the fungi, and fungus diseases of plants of the region, while Professor Underwood gave special attention to the ferns. In addition to large collections made in both these groups of plants an extensive general collection of plants was obtained.

Mr. Percy Wilson was absent from the Garden during January and February, making collections in Honduras, and brought back a large number of living plants, many of which have now been installed in the public conservatories, as well as an extensive series of herbarium and museum specimens.

Professor Underwood spent nearly four months on the island of Jamaica continuing his investigations of the ferns of tropical America, and brought back the largest single collection of herbarium specimens of these plants ever obtained

from that island, whose fern flora is the richest in the world, and these have been found to include a considerable number of species new to science. While in Jamaica, Professor Underwood collected a number of living plants for the conservatories and also made arrangements with the officers of the Public Gardens and Plantations there, to ship to the Garden a large number of living plants of which we had hitherto no satisfactory representation.

Dr. MacDougal spent parts of February and March in company with Mr. Frederick V. Coville, Chief of the Division of Botany of the U. S. Department of Agriculture, at the request of the Carnegie Institution, in determining the most desirable site for the new Desert Laboratory of that institution which has since been successfully established at Tucson, Arizona. During the trip he secured a considerable number of cacti and other succulents for the conservatories.

Dr. M. A. Howe was absent for about two months, in May and June, investigating the seaweeds of Porto Rico, of which a very large collection was obtained, and their study has disclosed a great amount of additional information relative to the algæ of the West Indies.

Professor F. E. Lloyd, of the Teachers College, accompanied by Mrs. Lloyd, explored the island of Dominica, leaving New York early in June and returning about the first of September. About two thousand herbarium and museum specimens were obtained, which greatly increase our representation of the flora of the Windward Islands.

Mr. Geo. V. Nash, accompanied by Harry F. Baker, spent August and part of September on the island of Haiti, and obtained a valuable collection of living plants, museum and herbarium specimens, of a flora of which our previous representation was very meager. They succeeded in penetrating into the interior of the Black Republic, reaching parts of it that had not previously been examined by botanists, and many of the plants obtained by them are of great interest.

I made two trips to the island of Cuba, one in March, accompanied by Mr. J. A. Shafer, and the other in August and

September, accompanied by Mr. Percy Wilson; Mrs. Britton was a member of both expeditions. About three thousand specimens were obtained on the two trips, including many species hitherto collected only once, and a number of botanical novelties.

Exploration in the Philippine Islands was inaugurated in September by sending Mr. R. S. Williams to Manila to make collections of plants and plant products, in coöperation with the Bureaus of Forestry and Agriculture of the insular government. Mr. Williams has arrived at Manila and commenced his work. It is hoped that he may be able to stay in the archipelago for a year or more and obtain a good representation of material for all the collections.

Dr. John K. Small explored the southern part of peninsular Florida during November and made a large collection of herbarium and museum specimens, which are now being studied. He discovered many species new to the United States, formerly known only from Cuba or the Bahamas, and some entirely new to science.

Investigations.

The facilities of the Garden for the furtherance of research have been increased by additions to the collections of books, living, fossil and preserved plants, and to the equipment of the laboratories.

The results of a large number of completed investigations have been brought out in the publications of the Garden and other periodicals, and others are in press.

Detailed memoranda of the activities of the members of the staff, and of the members of the faculties of coöperating institutions, are given below.

The results described have been accomplished in the intervals of the regular duties connected with the different departments of the Garden, and all of the members of the staff have participated in the guidance of registered investigators.

An account of the work of investigators registered for the privileges of the Garden is to be found in the report of the Director of the Laboratories.

Dr. D. T. MacDougal, first assistant and director of the laboratories, is carrying forward the study of the relations of soil-temperature to vegetation upon which subject he has published CONTRIBUTION 44. An investigation of correlations in leaves has been completed and published as CONTRIBUTION 43. His studies on the life-history of polymorphic aquatics, begun early in 1902, have been continued. In addition to results concerned with the influence of various external conditions upon structure and form, they may also be expected to furnish evidence upon the inheritance or non-inheritance of acquired characters.

Since May, 1902, Dr. MacDougal has been coöperating with Professor Hugo de Vries, Director of the Botanical Garden at Amsterdam, Holland, in testing certain features of the mutation theory of the origin of species recently proposed by him. One series of cultures of the parent species of the evening primrose, and mutant forms derived from it has been finished; a second series has been begun. An investigation of the influence of carbon monoxide, illuminating, and other gases upon plants has been undertaken in coöperation with Professor H. M. Richards, and some important results have already been obtained.

As a member of the Advisory Board of the Desert Botanical Laboratory of the Carnegie Institution, a tour was made in company with Frederick V. Coville, of the deserts in New Mexico, Chihuahua, Arizona, and California in February, 1903. A site for the laboratory was selected at Tucson, Arizona, and a building has been erected, which is now equipped and is open with its facilities for investigators. The results of the special studies of desert conditions have been brought out as Publication 6 of the Carnegie Institution under the title of "Desert Botanical Laboratory of the Carnegie Institution." Additional results have been published in the *Plant World* for November, 1903, and reprinted in the Garden publications as CONTRIBUTION 46. During the trip made in selecting a location for the Desert Laboratory, a number of living and preserved specimens of plants were secured by means of funds of the Garden.

Dr. John K. Small, curator of the museums, has continued his attention to the flora of southeastern United States, and has published the results of his work extending over the last ten years in an octavo volume of xii + 1,370 pages, in which there are descriptions of 6,364 species, 1,494 genera, 236 families and 62 orders, including all of the known flowering plants, ferns and fern allies of the portions of the United States south of the northern boundaries of North Carolina, Tennessee, Arkansas and the Indian Territory as far west as the one hundredth meridian. During the preparation of this work several hundred species new to science have been brought to light and the descriptions of others made more exact. Dr. Small has made himself familiar with many of these plants in their native habitats and since the publication of his book spent the month of November in the field near Miami, Florida, in the course of which some new species were obtained.

Dr. P. A. Rydberg, assistant curator, has continued his study of the flora of the Rocky Mountain region in the preparation of a manual covering that area. The results of his work on various groups and genera during the year have been published in CONTRIBUTIONS 36 and 37, in which several new species have been described. An annotated catalogue of the flora of Colorado has been brought to an advanced stage of completion and will be published soon by the College of Agriculture of Colorado.

Dr. Arthur Hollick, assistant curator, acting for the U. S. Geological Survey, examined the Cretaceous and Tertiary strata of Long Island in April and May, for the purpose of securing data as to the water supply of the island. On a second leave of absence he was detailed by the above bureau for field work in Alaska, and made an examination of the sections exposed along the Yukon River from the international boundary to the delta of the river. The purpose of this work was to make collections of fossils from the various horizons represented, especially from the Tertiary and Mesozoic beds. Dr. Hollick is also making a critical exami-

nation of Tertiary plants from the vicinity of the Potomac in Maryland. The geologic map of the Staten Island quadrangle of the New York City folio of the Geologic Atlas of the United States, compiled from data obtained by Dr. Hollick, has been recently published by the U. S. Geological Survey. The article on palaeobotany for the New International Encyclopedia was also prepared by Dr. Hollick. The results of other special studies upon fossil plants from Western America have been published in the JOURNAL and in CONTRIBUTIONS 28 and 31.

Dr. M. A. Howe, assistant curator, has continued his systematic study of the marine algae of North America. A thorough survey was made of the algal flora of the coastal region of the southern, western and northern parts of Porto Rico in May and June. A study of the genus *Riella* in coöperation with Prof. L. M. Underwood was published as CONTRIBUTION 34 of the Garden. A systematic study of the algae of the Bahamas is also being made.

Prof. F. S. Earle, assistant curator, made a collecting trip to eastern Cuba in March, and made a tour of Porto Rico investigating the plant diseases of the island for the office of the U. S. Experiment Stations. Work upon the Agaricaceae has been continued, and critical examinations of collections of fungi from California, Wyoming and Porto Rico, have been made and several new species described in various papers.

Miss A. M. Vail, librarian, has continued her special studies of Asclepiadaceae from various parts of the world, describing several new species, one of which is published in CONTRIBUTION 33.

Dr. J. H. Barnhart, editorial assistant, has brought his bibliographic work upon the local floras of North America to an advanced stage, and his results will be published as a MEMOIR at an early date.

Dr. W. J. Gies, consulting chemist, and adjunct professor of physiological chemistry in Columbia University, has under way investigation of the coloring substances and enzymes of the Sarracenias, together with other work on vege-

table pigments. The results of some researches upon the physiological influence of the heavy metals upon plants, obtained in coöperation with Dr. R. H. True, were published in the *Bulletin of the Torrey Botanical Club* for July, 1903.

Mrs. E. G. Britton, voluntary assistant, has continued her studies of the mosses of Cuba, Porto Rico, Haiti, and the continent of North America. The results of critical studies on various genera have been published in bryological journals. Accessions to the herbarium of mosses aggregating over four thousand specimens have been received, studied and distributed. Investigations of the morphology and life-history of *Vittaria* begun in 1901 have been continued. A paper on this subject in coöperation with Miss A. Taylor was published in the *Memoirs of the Torrey Botanical Club*, Vol. 8, No. 3, 1902.

Mr. R. S. Williams, collector in the Philippines, made a critical study of the mosses from the Yukon collected by Prof. J. M. Macoun in 1902, some of the results of which were published, and also examined the mosses of the Harriman Expedition to Alaska. Mr. Williams also studied a collection from Cape Nome, Alaska. The first installment of the enumeration of the mosses collected by Mr. Williams in Bolivia was published in BULLETIN No. 9; here 143 species were critically described, three new genera and thirty species of which were new to science. He also prepared sets of these mosses for distribution to other institutions.

Mr. Williams was appointed collector for the Garden in the Philippines, and started for the scene of his duties in September.

Dr. H. H. Rusby, curator of the economic collections, has completed the preparation of the sections of Buck's Reference Handbook of the Medical Sciences relating to materia medica and therapeutics, comprising volumes VI to VIII inclusive. He has also completed his part of the work on the botany and materia medica of the U. S. Pharmacopoeia, eighth decennial revision, now in press. Work on other publications has been carried forward. He has also made pre-

liminary studies of the plants collected by Mr. R. S. Williams in Bolivia, in 1901 and 1902. An illustrated paper on one of the plants yielding "Honduras" sarsaparilla, previously unknown, was published in the *Druggists Circular* for 1903. The results of a study on the jaborandi leaves of the New York market have been brought out in an illustrated paper in the *Bulletin of Pharmacy* for 1903. Work on collections from Colombia has been continued. The results of some studies upon vegetable foods, and upon beverages of vegetable origin, were given as illustrated lectures at the Garden and published in the JOURNAL.

Mr. Geo. V. Nash, head gardener, has continued his work on the grasses and economic plants in general. Some special studies have been made upon the grasses of Porto Rico, the results of which were published as CONTRIBUTION 39. Critical examinations were also made of a number of other groups, that of the Fouquieriaceae being brought out as CONTRIBUTION 42.

My own work, outside of the time required for administrative duties and the supervision of construction operations, has been devoted to aiding the several departments; the vast amount of material which has been received for the museums and herbarium has caused me to give special attention to the work of the curators in its proper determination and installation. A paper on "New or Noteworthy North American Crassulaceae," prepared conjointly with Dr. J. N. Rose, of the United States National Museum, was published in the BULLETIN.

Dr. L. M. Underwood, professor of botany, Columbia University, spent the period from January to May inclusive, in an extended field examination of the ferns of Cuba and Jamaica. The results of critical studies upon *Botrychium* were published in the *Bulletin of the Torrey Botanical Club* for January, 1903, and a résumé of our knowledge of the ferns of the Philippines in the same journal for December, 1903.

Dr. C. C. Curtis, tutor in botany, Columbia University, has been engaged in observations on the habits, occurrence and distribution of the forest trees of North America.

Dr. H. M. Richards, adjunct professor of botany in Barnard College, Columbia University, has completed his investigations upon the influence of wounding on turgidity and is carrying forward some work upon the influence of carbon monoxide, illuminating gases and other gases upon plants, in coöperation with Dr. D. T. MacDougal.

Dr. Tracy E. Hazen, tutor in botany, Barnard College, Columbia University, has continued his work on the Confervæ of North America. The results of his earlier studies have been published in the *Memoirs of the Torrey Botanical Club*, Volume 11.

Miss Ada Watterson, assistant in botany, Teachers College, Columbia University, has continued her observations on the effect of chemical irritants on the respiration of fungi, and has also carried forward some investigations on the cytology of hybrids.

Dr. E. S. Burgess, professor of biology, Normal College, has continued his investigations of the asters. The bibliography of the subject was published as Vol. 10 of the *Memoirs of the Torrey Botanical Club*. The systematic treatment of the group, including a number of new illustrations, has been brought to an advanced stage of preparation.

Investigations at other Institutions.

By means of the appropriation made for this purpose, Professor L. M. Underwood, Chairman of the Board of Scientific Directors, visited during the summer, many of the larger botanical establishments in Europe for the purpose of prosecuting his studies on the ferns of tropical America, and while engaged in this work, secured a large number of specimens for our collections, and some books for the library, by making exchanges with the gardens and museums visited by him.

Miss Anna M. Vail, librarian, took advantage of the opportunity while in France in the spring, for the purpose of attending the sale of the botanical library of the late Professor Jordan, of visiting the botanical establishments in Paris, and made a trip to Holland and Belgium. Through this

work several thousand specimens and many books were obtained for the collections, and exchange arrangements were perfected with several institutions.

Dr. John K. Small, curator of the museums and herbarium, spent some time studying the collections at Harvard University, at the Academy of Natural Sciences of Philadelphia, and at the National Museum at Washington, D. C.

Research Scholarships.

The action of the Board of Managers in the establishment of Resident Research Scholarships at the last annual meeting appears to be amply justified by the results. Research scholarships have been granted to five persons for an aggregate period of fourteen months.

Dr. Theodor Holm, of Washington, D. C., held a scholarship one month and made a critical study of the Ranunculaceae of North America and revised the labels of the collection of specimens of this family in the herbarium. Dr. Holm also determined the collection of Rocky Mountain sedges in the herbarium, as an aid to Dr. Rydberg in the preparation of his manual of Rocky Mountain botany.

Dr. B. E. Livingston, assistant in physiology in Chicago University, held a scholarship for four months within which period he completed an investigation of the chemical physiology of the cell, and obtained important results as to the toxic, physiologic and morphologic effects of a large number of mineral salts when used in minute and common concentrations in nutritive media.

Miss W. J. Robinson, instructor in botany at Vassar College, held a scholarship six months and completed certain morphological studies on orchids, on the Fouquieriaceae, and on the formation of tubers in general. A critical study of the fungus genus *Cordyceps* was made, and some work was begun in chemical physiology which will be continued at Vassar.

Mr. C. L. Shear, pathologist of the Bureau of Plant Industry, Washington, D. C., held a scholarship one month,

during which period he made a critical study of the family Valsaceae, and determined the collection of this family in the herbarium.

Mr. A. D. Selby, physiologist and pathologist to the Agricultural Experiment Station at Wooster, Ohio, held a scholarship two months in continuation of earlier registration and made an extended investigation of the latex of a number of native plants with a view to ascertaining whether any of these species might be taken to give promise of rubber in commercial quantity, and also for the purpose of finding out the function of latex. A fairly complete bibliography of the entire subject was compiled. Mr. Selby also completed some morphological studies of etiolated plants, and an investigation of the life history of a fungus parasitic on grapes.

Publications.

Bulletin No. 8, comprising pp. 409–518, with plate 42 of Vol. II, which it completed, was issued March 18, 1903. This number is devoted wholly to the reports of officers and committees for the year 1902.

Bulletin No. 9, comprising pp. 1–174, and plates 43–57 of Vol. III, was issued November 11. This number includes four scientific papers which were published separately in advance. The first, New or Noteworthy North American Crassulaceæ, by Dr. N. L. Britton and Dr. J. N. Rose, was issued on September 12, 1903. The second, The Flora of the Matawan Formation (Crosswicks Clays), by Mr. Edward W. Berry, was issued September 12, 1903. The third, Bolivian Mosses, Part I, by Mr. R. S. Williams, was issued October 19, 1903. The fourth paper, The Dimensional Relations of the Members of Compound Leaves, by Mr. Chas. Zeleny, was issued October 23, 1903.

The Journal has been issued monthly during the year, and the completed volume contains viii + 238 pages, with 8 plates and 29 figures.

Memoirs, Vol. II, The Influence of Light and Darkness upon Growth and Development, by Dr. D. T. MacDougal,

and comprising xiii + 319 pages with 176 figures, was issued January 20, 1903.

CONTRIBUTIONS No. 31–48 have been printed during the year, and include the following papers:

No. 31. A fossil petal and a fossil fruit from the Cretaceous (Dakota group) of Kansas, by Dr. Arthur Hollick.

No. 32. The Polyporaceæ of North America — II. The genus *Pyropolyporus*, by Dr. W. A. Murrill.

No. 33. Studies in the Asclepiadaceæ, by Miss A. M. Vail.

No. 34. The genus *Riella* with descriptions of new species from North America and the Canary Islands, by Dr. M. A. Howe and Prof. L. M. Underwood.

No. 35. The Polyporaceæ of North America — III. The genus *Fomes*, by Dr. W. A. Murrill.

No. 36. Studies on the Rocky Mountain flora — X, by Dr. P. A. Rydberg.

No. 37. Some generic segregations, by Dr. Per Axel Rydberg.

No. 38. The Polyporaceæ of North America — IV. The genus *Elfvingia*, by Dr. W. A. Murrill.

No. 39. A preliminary enumeration of the grasses of Porto Rico, by George V. Nash.

No. 40. The phyllodes of *Oxypolis filiformis*, a swamp xerophyte, by Miss Rosina J. Rennert.

No. 41. The Polyporaceae of North America — V. The genera *Cryptoporus*, *Piptoporus*, *Scutiger* and *Porodiscus*, by Dr. W. A. Murrill.

No. 42. A revision of the family Fouquieriaceae, by George V. Nash.

No. 43. Some correlations of leaves, by Dr. D. T. MacDougal.

No. 44. Soil-temperatures and vegetation, by Dr. D. T. MacDougal.

No. 45. Studies in plant hybrids, by Dr. W. A. Cannon.

No. 46. Some aspects of desert vegetation, by Dr. D. T. MacDougal.

No. 47. Anatomy and physiology of *Baccharis genistelloides*, by Miss E. M. Kupfer.

No. 48. Mutations in plants, by Dr. D. T. MacDougal.

Preservation of Native Plants.

Interest in the subject of the protection of wild flowers and of natural woodlands has been increased by the aid of the income of the fund of $3,000 established in 1901 by the Misses Olivia E. and Caroline Phelps Stokes; a portion of the income was used in defraying the expenses of a series of lectures delivered in ten eastern cities in the spring by Mr. C. L. Pollard, Secretary of the National Society for the Preservation of Wild Flowers; one of these lectures was delivered at the Garden. Another part of the income was used for the distribution of printed documents referring to the topic.

The Scientific Directors have authorized for 1904, the expenditure of the income along three lines: (A) Payment for prize essay on wild flower preservation; (B) arrangements for additional lectures; (C) the printing of notices to be posted where found desirable and practicable.

Reports Appended.

I submit, also, reports by the Curator of the Museums and Herbarium, the Curator of the Economic Collections, the Director of the Laboratories, the Librarian, the Head Gardener, the Superintendent of Buildings and Grounds, and a schedule of expenditures under appropriations by the Board of Managers.

Respectfully submitted,

N. L. Britton,

Director-in-Chief.

REPORT OF THE CURATOR OF THE MUSEUMS AND HERBARIUM.

DR. N. L. BRITTON, DIRECTOR-IN-CHIEF.

Sir: I have the honor to submit herewith my report as Curator of the Museums and Herbarium, for the year 1903:

The development of the collections and exhibits has been continued on the general plans outlined in my previous reports.

I. GENERAL ACCESSIONS. The several collections were increased by an aggregate of 85,750 specimens. From this aggregate, and from the store of previously acquired material, about 45,000 specimens of plants and plant-products have been incorporated in the permanent exhibits and study collections. From the same sources the duplicate collections were replenished. The specimens were obtained as follows:

(*a*) *Gifts and purchases.* A total of 31,878 specimens was thus added to the collections. This large increase to the resources of the institution came, not only through the direct gifts of specimens by members and friends of the Garden, but also by the gifts of money for the purchase of desirable specimens, in addition to the annual appropriation for the same purpose.

(*b*) *Exchanges.* The surplus museum and herbarium material comprising the duplicate collections, which were much depleted last year, were replenished during the early part of this year and again drawn on for exchange purposes. Through this source 19,407 specimens were obtained.

In addition to numerous individuals, exchange relations were established with the following institutions, thus increasing our exchange list to a total of fifty-nine:

Botanical Garden, Buitenzorg, Java.
Botanical Garden, Peradeniya, Ceylon.
Forest School, Yale University.
Royal University, Modena, Italy.
Public Gardens and Plantations, Jamaica.
California Academy of Sciences.

Jardin des Plantes, Paris.
University of Vermont.
University of Texas.

(*c*) *Exploration.* The activity in the field resulted in enriching the collections by a total of 34,465 specimens.

II. INSTALLATION OF NEW FURNITURE. The building of furniture according to plans mentioned in my last annual report, and the installation of the same during the earlier part of the year, has resulted in relieving the former congested condition of the collections and has given a more finished appearance to the halls and rooms.

III. PLANT PICTURE COLLECTION. This museum adjunct was increased by two hundred and fifty-five photographs and plates; the collection was largely drawn upon for plates during the readjustment of the systematic museum.

Museums.

1. ACCESSIONS. A total of 1,332 specimens was added to the museums during the year. Most of the specimens came as gifts or through the exploring trips maintained by the Garden. No attempt was made to notably increase the collections, chiefly on account of the installation of the furniture already referred to. However, towards the close of the year, after the exhibits had been readjusted in the new cases, the matter of increasing the collections with desirable and instructive specimens was undertaken and is being prosecuted.

2. PREPARATION OF MATERIAL FOR EXHIBITION, AND APPLIANCES. All specimens heretofore held in storage have been prepared to go into the exhibition cases or have been actually installed. Many valuable and interesting specimens have thus been put into use, and the collections are assuming a more finished appearance, as well as becoming more useful and instructive.

Scarcely any change was made in the style of appliances for exhibition purposes, but ring-stands and racks of special design were adopted and will be largely used during the coming year.

The permanent museum equipment has been increased as follows:

(*a*) *Exhibition blocks.* A few blocks of special sizes were secured during the year, while many blocks of the standard sizes from the supply secured last year were prepared and placed in the cases as they were needed.

(*b*) *Glass jars.* (Specimen-jar, 2605, Whitall Tatum Co.)

Diameter.	Height.	Number of jars.
2 inches.	5 inches.	60
2½ "	7 "	24
3 "	6 "	48
3 "	8 "	180
3¾ "	10 "	240
4½ "	12 "	180
	Total,	732

(*c*) *Oak frames, for displaying specimens mounted on cardboard, and plates and photographs.* Frames of the standard sizes amounting to a total of 1,081 were added to the museum equipment. This addition nearly completes the present requirements of the systematic museum.

3. Economic Museum. The amount of case-space added to that previously occupied by the economic collections amounts to about one hundred per cent., and about two thirds of the available space for cases on this floor is now occupied.

The standard cases are now grouped in rectangular blocks of four or six units. In the main east and west halls the blocks are composed of six units, while in the wings they are composed of four.

The specimens contained in the original equipment of cases have been spread out into the new cases and a large number of others, hitherto necessarily stored in the basement, have been interpolated; these are being permanently arranged as rapidly as the labels can be struck off by our printing outfit. Foods and fibers occupy the west hall; the former in cases on the north side, the latter on the south.

The west wing is mainly given over to exhibits other than foods, fibers, drugs and woods. The east hall contains the drugs, while the east wing is set aside for the woods and wood products.

The contents of the museum may be briefly outlined as follows: Blocks 1, 2 and 3 contain fibers. The cases adjacent to the center of the building, and the entrance, are given over to cotton and cotton products, the most important of the fibers of vegetable origin, while in the succeeding cases are displayed various other economic fibers and fiber-products arranged in the sequence of the natural families. Block 4 contains rubber and gums and resins. Block 5 is occupied by a collection of vanilla and tonka beans, licorice and spices. Block 6 is given over to fodders. Block 7 contains tobacco and plants and plant products used for chewing, and miscellaneous plant products. Block 8 contains various beverages. Block 9 is given over to the fixed and volatile oils, including the crude materials from which the oils are derived and their by-products. Block 10 contains the specimens of sugars and starches. Block 11 is divided between specimens of wood and straw papers and cork. Blocks numbered 12, 13 and 14, consisting of the same number of units that are given over to the fibers, are occupied by the foods. Here as in the case of the fibers the same general plan of arrangement has been adopted, thus the cases adjacent to the center of the building are given over to the specimens of the cereals, which taken together represent the most important foods of vegetable origin, and following these are the other foods, mostly fruits, primarily divided, as nearly as possible into two groups, the dry and the juicy, each group arranged in the sequence of the natural families.

The six blocks 15, 16, 17, 18, 19 and 20 contain the drug-plants and drugs. In these the specimens are divided into two series, which may be designated as crude drugs and prepared drugs. The crude drugs are arranged morphologically, beginning with the roots and rootstocks and followed by stems, barks, leaves, inflorescences, flowers, fruits, seeds and the whole plant.

The east wing is given over to the woods and wood-products. Blocks 21, 22, 23 and 24 contain specimens of woods from many parts of the world, while block 30 contains various wood-products and carbons. Blocks 25 to 35 are made of six cases of special design, devised to exhibit the North American trees by means of examples of the wood, accompanied by drawings, photographs and various illustrative specimens.

4. SYSTEMATIC MUSEUM. The addition of new cases necessitated the complete or partial readjustment of the several departments of this museum.

(*a*) *Synoptic collection.* The case equipment of this collection was about doubled, and this condition necessitated the installation of fully as many specimens as had been in use heretofore. These specimens are now at hand; many have been installed, others are in preparation and will soon be placed in the cases.

The display of algae has been doubled by the addition of specimens and plates mounted on cardboard, and specimens in jars. The display of fungi, lichens, hepatics, mosses and ferns and fern-allies is being increased in the same way as in the case of the algae. The display of the flowering plants has been more than doubled by the increased exhibits of the larger natural families and the addition of a plate representing a plant of each family.

This collection now occupies twenty-eight blocks of cases. Blocks 1, 2 and 3 contain the algae or sea-weeds, with the exception of the first section of block number one which is given over to the myxomycetes or slime-moulds. Blocks 4, 5, 6 and 7 contain the fungi, while the lichens occupy block 8. The hepatics are displayed in block number 9, the first section of which is also given to the Laboulbeniomycetes.

The mosses occupy blocks 10 and 11. Block 12, together with half of block 13, contains the ferns and fern-allies, while the rest of number 13 is given over to the gymnosperms. The remaining 15 blocks are devoted to the flowering plants.

(*b*) *Local flora.* Six new stands were added to the equip-

ment of this collection. This addition will enable us to exhibit the whole local flora, of which the lichens, hepatics, mosses, ferns and fern-allies, and flowering plants are now almost completely installed. Lack of time and assistance prevented the installation of the more lowly organized groups, but the cardboards for these plants are ready and many of the specimens have been selected and put aside for mounting.

(*c*) *Microscope exhibit.* Less change was necessary in the case of this display than in any other department, the results of the complete renovation to which it was subjected last year having proved satisfactory. This display continues to be very popular; the objects exhibited are changed from time to time.

5. Fossil Plant Museum. The addition of two new table-cases has resulted in a redistribution of the specimens in all the cases. Two cases are now devoted to Paleozoic plants; one to Jura-Trias; two to Cretaceous and one to Tertiary plants. This condition has resulted in a better exhibition of the Carboniferous flora than was previously possible and has provided room for the display of the exceptionally fine collection of Dakota group leaves obtained by the Garden last year. Specimens for display were selected and provided with blocks.

The contents of the wall-cases have been subjected to a slight rearrangement, in order to display the specimens to better advantage.

Critical examination of the collections has been continued and the work of identifying and marking type-specimens has been systematically carried on. The principal work of this character during the past year has been in connection with the collection illustrating the flora of the Amboy clays, which contains the types of Professor Newberry's monograph on the subject.

An important addition to the Museum is the collection of fossil plants of the Matawan formation, containing specimens of all the types of the species published in a paper on the flora of that formation recently printed in the Bulletin of the Garden.

6. Labeling. The permanent labeling of specimens was carried on as heretofore. Manuscript for the complete labeling of the economic museum was prepared and many of the permanent labels have been printed. Nearly all the manuscript for the systematic museum has been prepared and many of the labels have been struck off. The display of algae has been completely labeled, and large labels stating the object of the collection and the contents of each stand have been provided for the local flora. The permanent labeling of the table-cases of the fossil plant museum is about completed and general labels have been supplied for the wall-cases. Many of the labels printed during the early development of the museums have been replaced by more complete ones.

7. Care of the Collections. The general handling of specimens resulting from the moving of material from the old cases into the new, gave special opportunity for the examination and cleaning of specimens which had been in the cases for several years. The collections have suffered very little from exposure to the light and not at all from insect depredation.

The practice of poisoning specimens with mercuric chlorid, chloroform or carbon bisulphid has been continued and with satisfactory results.

8. Uses of the Museums. The several collections comprising the museums have been used to illustrate instruction given at the Garden and at Columbia University.

Instructors, students, and pupils of schools from New York City and the contiguous territory have made use of the collections both to gain general information and to illustrate courses of study. As heretofore the local flora and the microscope exhibit have maintained special interest, the former being used mostly by teachers and students, the latter especially attracting the general public. The economic collections have been a source of information to manufacturers, importers and merchants, as well as to the general public.

Herbaria.

1. Accessions. An aggregate of 84,163 specimens have been put to the account of the herbarium. All the desirable current distributions of herbarium specimens have been secured either as gifts or by purchase. The several exploring trips undertaken by the Garden have added thousands of valuable specimens, as well as some desiderata and many unique specimens to the collections.

The algal collections have been increased by fully 4,800 specimens, chiefly by several sets of exsiccatae and the collections of Dr. Howe in Porto Rico. The fungal collections have been increased by fully 9,300 specimens, mainly through the acquisition of several valuable exsiccatae and the collections of Mr. Earle in the West Indies and eastern North America. The bryophyte collections have been increased by at least 3,000 specimens, mainly from North America, tropical America and Europe. The collection of pteridophytes has been notably enlarged by the acquisition of the Jenman herbarium and the collections of Professor Underwood in the West Indies; the total addition of ferns and fern-allies amounting to fully 20,000 specimens. The more noteworthy additions of flowering plants came from North America, tropical America, including both the West Indies and the mainland, South America and southern Europe.

2. Mounting and Conserving of Herbarium Material.

(*a*) *Flat or pressed specimens.* Additions amounting to 33,254 sheets have been made to the herbaria. These sheets contain about 44,000 specimens, as in the case of the algae, fungi, lichens, hepatics and mosses, several specimens are usually mounted on a single sheet.

The accumulation of cryptogamic specimens has been mounted and incorporated in the herbaria. Noteworthy among this material is the Allen collection of Characeae and the Averill collection of Algae, and the algal material secured by Dr. Howe in Newfoundland, Bermuda, Florida and a vast number of mosses from all parts of the world. Most of the

current additions of flowering plants have been mounted and incorporated in the permanent collections.

The method of poisoning specimens with mercuric chlorid has been continued and as a result all apparent insect life has disappeared from the herbarium cases.

(*b*) *Bulky specimens.* A total of 4,600 specimens, mainly fungi, were permanently disposed in boxes of the following sizes:

Size of boxes.	Number of boxes.
5/8 x 2 5/8 x 3 7/8 inches.	1,000
1 1/4 x 2 5/8 x 3 7/8 "	600
1 1/4 x 5 1/4 x 3 7/8 "	300
2 1/2 x 2 5/8 x 3 7/8 "	400
2 1/2 x 5 1/4 x 3 7/8 "	300
2 1/2 x 5 1/4 x 7 3/4 "	500
Myxomycetes boxes	1,500
Total,	4,600

In addition to the fungi, the crustaceous and otherwise bulky lichens and the myxomycetes, heretofore merely stored, were placed in boxes and arranged in the cases so as to be accessible for study.

3. Arrangement of the Herbaria. Changes in the general arrangement of the herbaria were necessitated both on account of the growth of the collections and the disposition of the new furniture. The myxomycetes and algae occupy the laboratory directly west of the library reading room. The lichens, fungi and pteridophytes occupy the taxonomic laboratory. Adjacent to this laboratory and opening into it is a room devoted entirely to the collection of bryophytes. The main herbarium room is now given over to the seed-plants or flowering plants, those comprising the Garden herbarium being in the eastern side of the room, those comprising the Columbia herbarium on the west.

(*a*) *Garden Herbarium.* A total of 83,643 specimens was received for the Garden herbarium. From these and from sets of specimens previously acquired, 31,134 sheets, containing 41,200 specimens were mounted and incorporated in the permanent collections.

The herbaria merged into the Garden herbarium since the printing of the list of herbaria in my report for 1901, are as follows:

The O. R. Willis herbarium.
The J. S. Billings herbarium.
The L. M. Underwood herbarium.
The G. S. Jenman herbarium.
The F. S. Earle herbarium.
The W. A. Murrill herbarium.
The E. G. Britton herbarium.
The T. F. Allen herbarium.
The A. Henry herbarium of Chinese plants.
The A. Vigener herbarium.
The American Museum of Natural History herbarium.
The Torrey Botanical Club herbarium.

The local herbarium, comprising the plants growing naturally within a radius of one hundred miles of New York City, has been increased by specimens collected by members of the Garden staff and by representatives of the Garden detailed to accompany the Torrey Botanical Club on its weekly field meetings. This collection is gradually being renovated; the bryophytes have been completely remounted and many specimens added.

(*b*) *Columbia Herbarium.* Specimens amounting to a total of 520 were received for the Columbia herbarium. A total of 2,120 sheets containing 2,800 specimens was mounted for this collection. The work of remounting miscellaneous specimens and of strapping the specimens of the genera and families most handled has been prosecuted throughout the year. Considerable time has been devoted to the renovation of portions of the cryptogamic divisions of the collection, while such portion of the Morong herbarium as were needed for study were permanently mounted.

4. Duplicate Herbarium. This collection was replenished early in the year by the addition of extra specimens from the several exploring trips and by a very large collection of Rocky Mountain plants and miscellaneous specimens.

Later in the year active exchanging was maintained and a total of over 15,000 specimens was sent to other institutions and individuals.

5. USES OF THE HERBARIUM. Members of the Garden Staff have drawn on this source of information in developing their departments, as an adjunct in teaching in connection with the courses of instruction, for research work and special investigation. The registered students of the Garden and Columbia University have had access to these collections as their studies and investigations required.

Officers and students from other institutions have from time to time consulted these collections as investigations which they were prosecuting demanded, and other responsible individuals have been permitted to draw upon this source of information by special permission.

Assistance.

As heretofore the detail work connected with the maintenance and development of this department has been divided between several members of the staff, volunteers and aids. Dr. Rydberg has shared the curatorial work connected with the flowering plants. The work in connection with the cryptogams has been shared by several, Professor Underwood caring for the ferns and fern-allies, Mrs. Britton for the mosses and moss-allies, Mr. Earle for the fungi and allied groups and Dr. Howe for the algae. The fossil plant collections have been under the care of Dr. Hollick.

Respectfully submitted,

J. K. SMALL,

Curator of the Museums and Herbarium.

DECEMBER 31, 1903.

REPORT OF THE CURATOR OF THE ECONOMIC COLLECTIONS.

Dr. N. L. Britton, Director-in-Chief.

Sir: I have the honor to submit the following report of he Economic Museum for the year 1903.

The most important events of the year in the development of this museum have been the installation of new cases, and the transfer of the care of the collections to a single experienced custodian.

The increase in our case room is estimated at about 100 per cent.; but this figure does not fully state the advantage derived from the increase, since the change has involved a great improvement in the form of the cases. Each block, or set, of cases has been considerably enlarged, a change which allows a more effective display of sets of specimens which are extensive and which require a close relation throughout the series. The improved form of the cases has resulted in eliminating the interspaces which formerly existed, and which acted as annoying traps for the accumulation of dirt.

The change referred to has enabled us to place on exhibition several hundred specimens previously in storage, and to resume active operations looking toward farther acquisitions.

The considerable extension of the museum thus effected, and that promised for the future, has made it necessary that some properly qualified person should be continually in charge, and keep himself familiar with day-to-day developments and changes. By the readjustment of assistants arranged by you, this important desideratum has been secured.

Mr. J. A. Shafer, who has been appointed Custodian, having been educated as a pharmacist, and having had practical experience in museum work at the Carnegie Museum of Pittsburg, possesses special qualifications for this work.

The resignation in August last of our experienced printer, has interrupted the work of labeling new specimens, and substituting improved labels for the temporary ones previously in

place, but it is hoped that an arrangement can soon be made for resuming this work, probably the most important of any now before us.

The collection of North American woods, being accumulated in the eastern wing, under your own direction, has assumed important proportions, and will shortly provide excellent facilities for the study of this subject.

Among the more important acquisitions of the year are the following.

A series of specimens of tonka beans and coumarin, donated by Messrs. Dodge and Olcott, of New York.

A collection of plants used as medicines by the Cheyenne Indians, donated by Mr. George Bird Grinnell, of New York City.

A large collection of miscellaneous specimens obtained in exchange from the Field Columbian Museum, of Chicago.

A collection of specimens obtained in Jamaica by Prof. D. T. MacDougal.

One hundred species of economic fungi, purchased from Mr. G. P. Clinton.

A number of specimens from Jamaica, donated by the Hon. Wm. Fawcett.

A collection of insect flowers and powders, donated by Messrs. McCormick & Co., of Baltimore.

A collection made in Dominica by Prof. F. E. Lloyd.

A collection of linseed oils, donated by the National Linseed Oil Company.

A collection made in Cuba and in Florida by Dr. and Mrs. N. L. Britton.

A collection made in Florida by Dr. J. K. Small.

A collection made in Georgia by Mr. R. M. Harper.

A collection of New Zealand woods donated by Mr. L. Cockayne.

A large collection of woods and miscellaneous specimens made in Haiti by Mr. Geo. V. Nash.

A number of important collections have been promised and will doubtless be received during the coming year.

One of the most important indications for the future of the museum is the necessity that must soon arise for appropriations for the purchase of specimens. Heretofore, we have relied chiefly upon donations by commercial houses. This resource, though by no means exhausted, cannot be relied upon so extensively as heretofore. A large number of the more important industries are now represented by rather complete sets of the ordinary articles of the market, but in nearly every case there are important gaps to be filled. The missing articles are often, by their very rarity, of greater interest than those possessed. For many of them, we cannot safely depend upon any other method than that of purchase, as opportunities present themselves. For this purpose, there should be a special fund appropriated, which could be drawn upon without a delay which might in some cases involve the loss of the opportunity. During the coming year, we shall doubtless find opportunity for full activity in working along old lines; but the suggestion here presented should receive consideration for our future needs.

Very respectfully,

H. H. Rusby, M.D.,

Curator of the Economic Collections.

REPORT OF THE DIRECTOR OF THE LABORATORIES.

DR. N. L. BRITTON, DIRECTOR-IN-CHIEF.

Sir: I have the honor to submit the following report for the year ending January 1, 1904.

The appropriation for the laboratories has been expended chiefly in securing additional microscopes and lenses, in the increase of the equipment for research in chemical physiology and in the purchase of supplies of all kinds for the increasing number of investigators. The usefulness of the laboratories has also been greatly increased by the construction of suitable wall-cases and shelving, by the aid of which the apparatus may be properly cared for and kept in order. Chemical desks and tables for the use of individual workers have also been added.

The collection illustrating the development and history of the microscope, donated by Mr. C. F. Cox, has been arranged for display by means of the additional necessary cases provided for that purpose.

Meteorological observations have been continued. The thermographic and precipitation records are filed in suitable volumes which contain the continuous series of observations begun in 1900. The total precipitation for the year amounts to 56.6 inches. The total number of days between the latest spring frost and the earliest freezing temperature of the autumn amounts to 170 days, in comparison with which it is interesting to note a similar period of 168 days in 1902. The results of the first years' observations with the Hallock soil thermograph have been discussed in a paper published in the *Monthly Weather Review* of the United States Weather Bureau for August, 1903, and reprinted as CONTRIBUTION 44 in the Garden series.

The results of my investigations upon the influence of light and darkness upon growth and development of plants, completed in the previous year, are set forth in Vol. II of the

MEMOIRS of the Garden, which was issued under date of January 20, 1903.

The duties of the Director-in-Chief were discharged during the absences of Dr. N. L. Britton in March and December. Editorial work in connection with the Torrey Botanical Club has been performed, and the duties of Secretary of the Botanical Society of America have been discharged during the year.

Photographic equipment has been provided for the several expeditions sent by the Garden to various parts of the world. Selections are made from the negatives secured by such means, which are registered and placed in the permanent collection, which now includes about 400. Lantern slides are made from the reserved negatives and from others as well, which are used in illustrating the lectures of the spring and autumn courses. These slides are also used by members of the staff in lectures given in other institutions. The most valuable addition to this collection consists of a series, 340 in number, donated by Mr. C. F. Cox, of the Board of Managers. This series was made by Mr. T. F. Smith, of London, and illustrates the theory of structure of diatoms as described by him in the *Journal of the New York Microscopical Society* for April, 1891. The collection of slides now amounts to about 1,200.

The experimental greenhouse and the adjacent ground in the nursery are proving of very great service in investigations in physiology, morphology and mycology. Since May, 1902, I have been coöperating with Professor Hugo de Vries, Director of the Botanical Garden at Amsterdam, Holland, in testing certain features of the mutation theory of the origin of species recently proposed by him. One series of cultures of the parent species of the evening primrose, and mutant forms derived from it, has been finished, and the results published in the *American Naturalist* for November, 1903, and reprinted as CONTRIBUTION 48 in the Garden publications. A second series has been begun. This work is of unusual interest, since it is concerned with the only known instances

where new forms of the rank of species have been observed to originate, under circumstances properly guarded against error.

My investigations on correlations in leaves were finished and the results published in the *Bulletin of the Torrey Botanical Club* for September, 1903, being reprinted as CONTRIBUTION 43 of the Garden publications.

The studies on the life-history of polymorphic aquatics begun early in 1902 have been continued. This work entails extended cultures of aquatics under normal conditions, aquatics as terrestrials, and terrestrial species as aquatics during several seasons, and in addition to results concerned with the influence of various external conditions upon structure and form may also be expected to furnish evidence upon the inheritance or non-inheritance of acquired characters.

Dr. H. M. Richards has undertaken with me an investigation of the influence of carbon monoxide and other gases upon plants. During the few months that cultural tests have been under way marked results of some importance have been secured which will be announced in due form after the work has been completed. It has been found necessary to take up the study of the effects of illuminating gas upon plants in connection with these experiments.

During July, 1903, a trip was made to Jamaica for the purpose of arranging with the government a lease of Bellevue House and grounds at Cinchona. This establishment was found to offer exceptional facilities for botanical investigations in the tropics, and the grounds placed at the disposal of the Garden will be of great service in the collection and forwarding of living plants for the Garden collections. My wife and daughter accompanied me on this trip, and we found the summer climate of Jamaica healthful and pleasant.

Arrangements were made with the Hon. Wm. Fawcett, Director of the Public Gardens and Plantations of Jamaica, by which the Garden received the duplicate herbarium specimens accumulated by his department, including about 5,230 specimens.

Special Investigations.

The following alphabetical list contains the names of all persons to whom the privileges of the Garden have been granted for extended periods during the year, together with brief notes as to the special investigations pursued while in residence.

JOSEPH CHARLES ARTHUR. Iowa State College, B.S., 1872; M.S., 1877; Cornell University, D.Sc., 1886. Professor of Plant Physiology and Pathology, Purdue University, and Botanist to the Agricultural Experiment Station.

Cultural and morphological investigation of the plant rusts.

HARRIET BROWN BAILEY.

The flora of northeastern America with special attention to the mosses of this region.

HOWARD JAMES BANKER. Syracuse University, A.B., 1892; Columbia University, A.M., 1900. Instructor in the Southwestern State Normal School, California, Penn.

A study of the Hydnaceae.

MARY FRANKLIN BARRETT. Smith College, B.L., 1901.

Taxonomy of the Tremellales.

ELIZABETH BILLINGS.

A systematic study of the grasses of Vermont.

LAURA BAKER BROOMALL. University of Michigan, B.S., 1898.

Embryology of certain seed-plants.

CHARLES THOMAS BRUES. University of Texas, B.S., 1901; M.S., 1902.

General morphology of the algae.

ESTHER FUSSELL BYRNES. Bryn Mawr College, A.B., 1891; A.M., 1894; Ph.D., 1898. Instructor in biology in Girls' High School, Brooklyn, N. Y.

An investigation of the factors which determine sex in dioecious plants.

WILLIAM AUSTIN CANNON. Stanford University, A.B., 1899; A.M., 1900; Columbia University, Ph.D., 1902. Later appointed resident investigator, Desert Botanical Laboratory of the Carnegie Institution, Tucson, Arizona.

Spermatogenesis of hybrids.

Anna May Clark. University of Vermont, Ph.B., 1898.
The life-histories of selected cryptogams.

Alice Dufour. Defiance College, Ph.B., 1899.
A systematic study of the grasses of the tribe Oryzeae.

Julia Titus Emerson. Appointed assistant in the laboratories, Sept., 1903.
An investigation of a disease of the roots of *Rosa* caused by parasitic organisms, and of the chemical properties of *Ibervillea*.

Elizabeth Venable Gaines. Adelphi College, A.B., 1899. Instructor in biology in Adelphi College.
Taxonomic study of the Berberidaceae and Menispermaceae.

Leon Everett Grout. University of Vermont, B.S., 1902.
The embryology of certain members of the Rubiaceae.

Benjamin Charles Gruenberg. University of Minnesota, B.S., 1896. Sugar-testing laboratory, U. S. Appraisers' Stores, N. Y. City. Instructor in biology in High Schools, N. Y. City.
Chemical and anatomical examination of *Haematoxylon*.

Roland McMillan Harper. University of Georgia, C.E., 1897.
The flora of Georgia.

Caroline Coventry Haynes.
A systematic study of some of the Hepaticae.

Florence Henry. Cornell University, A.B., 1901; Columbia University, A.M., 1902.
Palaeobotany.

Theodor Holm. Catholic University of America, Ph.D., 1902.
Investigation of the taxonomy and morphology of the Ranunculaceae, and of Rocky Mountain *Carices*. Research scholarship for one month.

William Titus Horne. University of Nebraska, B.S., 1898. Further work at same institution, 1898–1900. Fellow in Columbia University, 1903–1904.
Parasitic diseases of plants; formation and significance of alkaloids in plants.

Homer Doliver House. Syracuse University, B.S., 1902. Later appointed assistant in botany, Columbia University.
A systematic and anatomical study of the Convolvulaceace, and an experimental series of observations on carpotropic movements. Influence of ions upon seedlings.

FLORA ISHAM.

A taxonomic study of the sedges of the local flora.

CYRUS AMBROSE KING. State University of Indiana, A.B., 1893; Harvard University, A.B., 1897; A.M., 1898; Ph.D., 1902.

Cytology of the Phycomycetes.

ELSIE M. KUPFER. Columbia University, A.B., 1899; A.M., 1901. Instructor in biology in Wadleigh High School Annex.

An anatomical and physiological study of *Baccharis genistelloides*, and a series of studies upon the subject of regeneration of plants.

MARION ELIZABETH LATHAM. Columbia University, A.B., 1903.

Investigation of the stimulating effect of chloroform on the growth of fungi.

GEORGE LEAVENWORTH. University of Missouri, A.B., 1902.

A systematic study of the trees of the Mississippi basin.

BURTON EDWARD LIVINGSTON. University of Michigan, B.S., 1898; University of Chicago, Ph.D., 1902. Assistant in plant physiology, University of Chicago.

The effect of chemical stimulation upon the form and structure of plants. Research scholarship for four months.

LUCY MACINTYRE.

Morphology of certain algae.

NINA LOVERING MARSHALL. Wellesley College, A.B., 1895. Instructor in science department of Ely's School, N. Y. City.

A study of the mosses, lichens, and hepaticae, in the preparation of a popular book upon this subject.

WILLIAM RALPH MAXON. Syracuse University, Ph.B., 1898. Aid in cryptogamic botany, United States National Museum.

The ferns and fern-allies of Jamaica.

CHARLES FREDERICK MILLSPAUGH. Student, Cornell University, class of '75; New York Homeopathic Medical College, M.D., 1881. Curator, Department of Botany, Field Columbian Museum.

The flora of the West Indies.

ERNESTINE MOLWITZ. Columbia University, A.B., 1902.

An anatomical and chemical examination of *Ibervillea Sonorae*.

FANNIE AUGUSTA MULFORD.

A study of the flora of the plains of Long Island.

WILLIAM ALPHONSO MURRILL. Virginia Polytechnic Institute, B.S.A., 1886; B.M. and B.S., 1887; Randolph-Macon College, B. S., 1889; A.B., 1890; A.M., 1891; Cornell University, Ph.D., 1900.

A systematic study of the Polyporaceae of North America.

ROSINA JULIA RENNERT. Normal College of N. Y. City, A.B., 1897; Columbia University, A.B., 1901; A.M., 1902.

An anatomical and physiological study of *Oxypolis filiformis*.

CHARLES BUDD ROBINSON. Dalhousie University, A.B., 1891; student at Cambridge University, England.

The Characeae of eastern America; carpotropic movements of plants.

WINIFRED JOSEPHINE ROBINSON. Michigan State Normal School, B.Pd., 1892; University of Michigan, B.S., 1899.

The physiology of the formation of tubers, and a taxonomic study of *Cordyceps*. Research scholarship for six months.

AUGUSTINE DAWSON SELBY. Ohio State University, B.S., 1893. Botanist and chief of the department of plant physiology and pathology of the Ohio Agricultural Experiment Station.

Investigations in the chemical physiology of plants, and of fungal parasites affecting the grape. Research scholarship for one month.

CORNELIUS LOTT SHEAR. University of Nebraska, A.M., 1898. Pathologist, United States Bureau of Plant Industry.

Taxonomy and morphology of fungi. Research scholarship for one month.

HERVEY WOODBURN SHIMER. Lafayette College, A.B., 1899; M.A., 1901.

Palaeobotany.

MARGARET SLOSSON.

A study of the early stages of certain ferns.

STELLA GEORGIANA STREETER. Smith College, B.L., 1898.

A study of the transpiratory openings of the Marchantiaceae.

WILLIAM CULLEN UHLIG. Columbia University, Ph.B., 1896.

General morphology of the algae in the water-supply of New York City.

IRVING TUPPER WORTHLEY. Student in the Cornell Forest School, 1900–1902.

Native and cultivated shrubs.

NAOHIDÉ YATSU. Tokyo University, Rigakushi (B.A.), 1900.
Cytological changes produced by chemical stimulation.

CHARLES ZELENY. University of Minnesota, B.S., 1898; M.S., 1901.
An experimental investigation of correlations, comprehending a study of the dimensional relations of the members of compound leaves.

The total registration for the year 1903 includes 46 persons, who represent by degrees received, or by incumbencies held, 40 institutions of collegiate rank or scientific purpose. 3 have held research scholarships for periods of one month, 1 for four months and 1 for six months.

Respectfully submitted,

D. T. MACDOUGAL,
Director of the Laboratories.

REPORT OF THE LIBRARIAN.

To the Director-in-Chief.

Sir: I have the honor to submit the following report on the Library, covering the period from January 1, 1903, to January 1, 1904.

A census of the library was taken on December 28, and the number of bound volumes was then found to be 14,591, showing an increase for the year of 1,656 volumes. Of these, 513 volumes were purchased by the special book fund, 278 volumes were purchased by the library appropriation, 493 volumes were presented to the Garden and 17 volumes were deposited by Columbia University, the remainder being acquired through subscription or exchange.

During the year 985 volumes have been bound, of which 148 volumes were serials and pamphlets deposited at the Garden by Columbia University.

The card-catalogue has been kept up to date; about 5,000 written cards have been added to it. Besides the set of cards of the *Index to recent literature relating to American botany*, published by the Torrey Botanical Club, that is sorted into the general card index, the Library also maintains a complete set of this index in a separate series. This is also the case with the *Card-index of genera, species and varieties of plants* published since 1885, compiled by Josephine A. Clark, and the *Index botanique universel* published by the Herbier Boissier. The overcrowding of the cards in the case used heretofore necessitated the construction of a special card-index case against one of the piers in the reading room, and this new case was put in place by the Library Bureau early in the year and the cards moved into it. The subject catalogue has been notably increased. During the year the book-cases built into the reading room in 1902 have been filled, this necessitating the rearranging and moving of a number of books, which was deferred till the early part of the year, when steel shelving for nearly one

fourth more volumes was placed in the stack-room. The increase of books this year has however nearly filled them.

A large octagonal table has been constructed for the center of the reading room. On it are now displayed the current periodicals. The lower portion of this table is fitted with shelves and doors, and provides space for the storing of miscellaneous unclassified collections such as letters, manuscripts and pictures.

The most notable addition to the library was the purchase in Paris during the month of May of some five hundred books and pamphlets at the auction sale of the botanical library of the late Professor Alexis Jordan. Of these, the most valuable, some 340 numbers, were the gift of Mr. Andrew Carnegie, the remainder being purchased through the special book fund.

Valuable gifts have been received from Mr. C. F. Cox, who presented the library with 80 volumes of books on microscopy, from Mr. Leonard Barron, and Dr. L. M. Underwood. Professor F. S. Earle has presented over 600 miscellaneous unbound pamphlets, many of which have filled gaps in incomplete serials. The Library of Columbia University has also given from time to time a number of unbound dissertations on botanical subjects that have proved very acceptable additions to the existing collections. A number of horticultural and agricultural publications have also been received from the same source.

Additional exchanges with other institutions have been arranged, and the number of journals, periodicals and reports now received in that way in exchange for Garden publications is 305, as against 257 during 1902. The number of journals subscribed for is now 30, as against 20 received last year.

Accessions to the Library other than serials and regular exchanges, have been published monthly in the JOURNAL.

Respectfully submitted,

ANNA MURRAY VAIL,

Librarian.

List of Exchanges.

Institutions.

Agricultural Experiment Station, Auburn, Ala.
“ “ “ Tuskegee, Ala.
“ “ “ Uniontown, Ala.
“ “ “ Tucson, Arizona.
“ “ “ Fayetteville, Ark.
“ “ “ Berkeley, Calif.
“ “ “ Fort Collins, Colo.
“ “ “ New Haven, Conn.
“ “ “ Storrs, Conn.
“ “ “ Newark, Del.
“ “ “ Lake City, Fla.
“ “ “ Experiment, Ga.
“ “ “ Honolulu, Hawaii.
“ “ “ Moscow, Idaho.
“ “ “ Urbana, Ill.
“ “ “ Lafayette, Ind.
“ “ “ Ames, Iowa.
“ “ “ Manhattan, Kans.
“ “ “ Lexington, Ky.
“ “ “ Baton Rouge, La.
“ “ “ Orono, Me.
“ “ “ College Park, Md.
“ “ “ Amherst, Mass.
“ “ “ Agricultural College, Mich.
“ “ “ St. Anthony Park, St. Paul Minn.
“ “ “ Agricultural College, Miss.
“ “ “ Columbia, Mo.
“ “ “ Bozeman, Montana.
“ “ “ Lincoln, Nebr.
“ “ “ Reno, Nev.
“ “ “ Durham, N. H.
“ “ “ New Brunswick, N. J.
“ “ “ Mesilla Park, N. Mex.
“ “ “ Geneva, N. Y.
“ “ “ Ithaca, N. Y.
“ “ “ Raleigh, N. C.

Agricultural Experiment Station, Fargo, N. Dak.
" " " Wooster, Ohio.
" " " Stillwater, Oklahoma.
" " " Corvallis, Oregon.
" " " State College, Pa.
" " " Mayaguez, Porto Rico, W. I.
" " " Kingston, R. I.
" " " Clemson College, S. C.
" " " Brookings, S. Dak.
" " " Knoxville, Tenn.
" " " College Station, Texas.
" " " Logan, Utah.
" " " Burlington, Vt.
" " " Blacksburg, Va.
" " " Morgantown, W. Va.
" " " Pullman, Washington.
" " " Madison, Wis.
" " " Laramie, Wyo.

Agricultural Bulletin of the Malay Peninsula, Singapore, Straits Settlements.

Agricultural Department of the West Indies, Barbadoes, W. I. *Bulletin*, "*Agricultural News.*"

American Museum of Natural History, New York City, N. Y. *Bulletin*, *Journal* and *Report*.

Bergianska Trädgärden, Stockholm, Sweden. *Acta Horti Bergiani.*

Bernice Pauahi Bishop Museum, Honolulu, Hawaii.

Biologisch-Landwirtschaftliche Institut in Amani, Deutsch-Ost-Afrika. *Berichte über Land und Forstwirthschaft.*

Botanic Garden, Imperial University, Tokyo, Japan. *Seed lists.*

Botanic Gardens, Singapore, Straits Settlements. *Annual Report.*

Botanic Gardens, Sydney, New South Wales. *Report.*

Botanic Institute of the University of Stockholm, Stockholm, Sweden. *Meddelanden.*

Botanical Garden, Belize, British Honduras.

Botanical Gardens, Cincinnati, Ohio.

Botanischer Garten der Grossh. Technischen Hochshule, Karlsruhe, Germany. *Seed lists.*

Brooklyn Institute of Arts and Sciences, Brooklyn, N.Y. *Science Bulletin* and *The Children's Museum Bulletin.*

Buffalo Botanic Garden, West Seneca, N. Y.

California State Board of Horticulture, Sacramento, California. *Report.*

Central Experiment Farm, Ottawa, Canada. *Bulletin, Report.*

Chicago University, Chicago, Illinois. *Contributions from the Hull Botanical Laboratory.*

Clara Leigh Dwight Gardens, Mount Holyoke, Mass. *Seed lists.*

College of Pharmacy, New York City, N. Y. *Journal of Pharmacology.*

Columbia University, New York City, N. Y. *Memoirs* and *Contributions from the Department of Botany.*

Denison University, Granville, Ohio. *Bulletin of the Scientific Laboratories.*

Desert Botanical Laboratory of the Carnegie Institution, Tucson, Arizona. *Report.*

Ecoles Moyenne et Supérieure de l'Etat, Wageningue, Holland. *Seed lists.*

Eli Lilly and Company, Indianapolis, Ind.

Field Columbian Museum, Jackson Park, Chicago, Ill. *Publications: Report Series* and *Botanical Series.*

Forestry Bureau, Manila, Philippine Islands.

Geological and Natural History Survey of Canada, Ottawa, Canada. *Contributions from the Herbarium.*

Geological and Natural History Survey of Maryland, Baltimore, Md.

Geological and Natural History Survey of Minnesota, Minneapolis, Minn. *Report* and *Bulletin.*

Hamburgische Botanische Staatsinstitute, Hamburg, Germany. *Seed lists.*

Harvard University, Cambridge, Mass. *Contributions from the Gray Herbarium*, and *Contributions from the Cryptogamic Laboratory.*

Herbier Boissier, Geneva, Switzerland. *Bulletin.*

Horticultural College, Swanley, England. *Report.*

Hortus Botanicus Academicus Dublanensis, Lemberg, Austria. *Seed lists.*

Hortus Botanicus, Christiania, Norway. *Seed lists.*

Hortus Botanicus, Lund, Sweden. *Seed lists.*

Hortus Botanicus, Utrecht, Holland. *Seed lists.*

Hortus Thenensis, Tirlemont, Belgium. *Icones Selectae.*

Illinois State Laboratory of Natural History, Urbana, Ill. *Bulletin.*

Institut Agronomique de Moscou, Moscow, Russia. *Annales.*

Institut Botanique de Bucarest, Bucarest, Roumania. *Bulletin de l'Herbier.*

Institut Botanique de l'Université, Brussels, Belgium. *Recueil.*

Institut Botanique de l'Université, Liege, Belgium. *Archives.*

Institut Botanique, Montpellier, France. *Seed lists.*

Institut Colonial de Marseille, Marseilles, France. *Annales.*

Instituto Fisico-Geografico de Costa Rica, San José de Costa Rica. *Boletin.*

Instituto Medico Nacional, Mexico City, Mexico. *Anales.*

Iowa Academy of Sciences, Des Moines, Iowa. *Proceedings.*

Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa. *Contributions from the Botanical Laboratory.*

Iowa State University, Iowa City, Iowa. *Bulletin of the Natural History Laboratories.*

Jamaica Department of Agriculture, Kingston, Jamaica, W. I. *Bulletin.*

Jardin Botanico de la Universidad, Havana, Cuba.

Jardin Botanique, Antwerp, Belgium. *Seed lists.*

Jardin Botanique de l'Etat, Brussels, Belgium. *Bulletin.*

Jardin Botanique, Geneva, Switzerland. *Bulletin du Laboratoire Général* and *Annuaire.*

Jardin Botanique de Buitenzorg, Batavia, Java. *Mededeelingen*, *Verslag* and *Bulletin.*

Jardin Botanique, Parc de le Tête d'Or, Lyons, France. *Seed lists.*

Jardin Botanique de la Faculté Mixte de Médecine et de Pharmacie, Lyons, France. *Seed lists.*

Jardin Botanique de l'Université de Groningue, Groningue, Holland. *Seed lists.*

Jardin Botanique "Jevremovac," Belgrade, Servia. *Seed lists.*

Jardin d'Acclimatation Alpin, Geneva, Switzerland. *Seed lists.*

Johns Hopkins University, Baltimore, Md. *Circulars.*

Kansas University Quarterly, Lawrence, Kansas.

Königl. Botanischer Garten, Munich, Bavaria. *Seed lists.*

Königl. Botanischer Garten und Museum zu Berlin, Berlin, Germany. *Notizblatt.*

Leland Stanford, Jr. University: Hopkins Seaside Laboratory, San Francisco, Cal. *Contributions.*

Leyden Botanic Garden, Leyden, Holland. *Delectus Seminus.*

Library of Congress, Washington, D. C.

Lloyd Mycological Museum, Cincinnati, Ohio. *Report; Mycological Notes, Reproduction Series* and *Bulletin.*

Manchester Institute of Arts and Sciences, Manchester, England. *Proceedings.*

Manchester Museum, Owens College, Manchester, England. *Reports* and *Publications.*

McGill University, Montreal, Canada. *Papers from the Department of Botany.*

Missouri Botanical Garden, St. Louis, Mo. *Report.*

Museo de Farmacologia, Buenos Aires, Argentine Republic. *Trabajos.*

Museo de La Plata, Provincia de Buenos Aires, Argentine Republic. *Anales.*

Museo Nacional de Montevideo, Montevideo, Uruguay. *Anales.*

Muséum d'Histoire Naturelle, Paris, France. *Bulletin du Muséum.*

National Botanic Garden, Washington, D. C.

New Jersey Agricultural Experiment Station, Trenton, N. J. *Report of the Botanical Department.*

New York Public Library, New York City, N. Y. *Bulletin.*

New York State Museum of Natural History, Albany, N. Y. *Annual Report.*

Oberlin College, Oberlin, Ohio. *Laboratory Bulletin.*

Ohio State University, Columbus, Ohio. *University Bulletin Botanical Series.*

Pennsylvania Department of Forestry, Harrisburg, Pa. *Report.*

Philadelphia Commercial Museum, Philadelphia, Pa.

Proefstation voor Suikerriet in West Java, Java. *Mededeelingen.*

Queens College Library, Kingston, Ontario, Canada.

R. Istituto Botanico di Palermo, Palermo, Italy. *Contribuzioni alla Biologia Vegetale.*

R. Orto Botanico di Palermo, Italy. *Bollettino.*

R. Orto Botanico di Siena, Siena, Italy. *Bullettino.*

R. Scuola Superiore di Agricoltura in Portici, Portici, Italy. *Annali* and *Bollettino*.

R. Stazione Agraria Sperimentale, Rome, Italy. *Bollettino*.

Royal Botanic Garden, Edinburgh, Scotland. *Seed lists*.

Royal Botanic Gardens, Peradeniya, Ceylon. *Annals*.

Royal Botanic Gardens, Trinidad, West Indies. *Bulletin of Miscellaneous Information*.

Royal Botanical Garden, Calcutta, India. *Annals*.

Royal Botanical Gardens, Glasnevin, Dublin, Ireland. *Seed lists*.

Royal Gardens, Kew, England. *Bulletin of Miscellaneous Information*.

St. Petersburg Botanical Garden, St. Petersburg, Russia. *Bulletin* and *Acta*.

Sharon Biological Laboratory, Sharon, Mass.

Shaw School of Botany, St. Louis, Mo. *Contributions*.

Smith College, Northampton, Mass. *Seed lists*.

Smithsonian Institution, Washington, D. C. *Report*.

Tromsø Museum, Tromsø, Norway. *Aarshefter*.

U. S. Department of Agriculture. *All publications*.

Weather Bureau and its 44 Sectional Departments.

Monthly Weather Review.

U. S. Department of State. *Publications of the Bureau of Foreign Commerce*.

U. S. Geological Survey, Washington, D. C. *Annual Report*, *Bulletin*.

University of California, Berkeley, California. *Contributions from the Botanical Seminary*, *Contributions from the Botanical Laboratory* and *Publications: Botany*.

University of Colorado, Boulder, Colo. *Studies*.

University of Nebraska, Lincoln, Neb. *Contributions from the Botanical Department*.

University Library, Upsala, Sweden. *Botanic reprints*.

University of Toronto, Toronto, Canada. *University Studies*.

Victoria Gardens, Bombay, India. *Report*.

Societies.

Académie Impériale des Sciences, St. Petersburg, Russia. *Bulletin*.

Academy of Natural Sciences, Philadelphia, Pa. *Proceedings*.

American Association for the Advancement of Science, Washington, D. C. *Proceedings*.

American Rose Society, New York City, N. Y. *Bulletin.*

Appalachian Mountain Club, Boston, Mass. "*Appalachia.*"

Asiatic Society of Bengal, Calcutta, India. *Journal.*

Association pour la Protection des Plantes, Geneva, Switzerland. *Bulletin.*

Biological Club of the Ohio State University, Columbus, Ohio. "*The Ohio Naturalist.*"

Biological Society of Washington, Washington, D. C. *Proceedings.*

Botanical Club of Canada, Halifax, Canada. *Annual Report.*

Botanical Society of America. *Publications.*

Botanische Gesellschaft zu Regensburg, Regensburg, Bavaria, Germany. *Denkschriften.*

Botanischer Verein der Provinz Brandenburg, Berlin, Germany, *Verhandlungen.*

Botanischer Verein in Landshut, Landshut, Bavaria. *Bericht.*

Buffalo Society of Natural Sciences, Buffalo, N. Y. *Bulletin.*

California Academy of Sciences, San Francisco, Calif. *Proceedings.*

Cincinnati Society of Natural History, Cincinnati, Ohio. *Journal.*

Connecticut Academy of Arts and Sciences, New Haven, Conn. *Transactions.*

Davenport Academy of Sciences, Davenport, Iowa. *Proceedings.*

Deutsche Dendrologische Gesellschaft, Poppelsdorf bei Bonn, Germany. *Mitteilungen.*

Edinburgh Botanical Society, Edinburgh, Scotland. *Transactions.*

Elisha Mitchell Scientific Society, Chapel Hill, N. C. *Journal.*

Flower Preservation Society of America, Washington, D. C. *Circulars.*

Geographical Society of Philadelphia, Philadelphia, Pa. *Bulletin.*

Hamilton Scientific Association, Hamilton, Ontario. *Journal and Proceedings.*

Horticultural Society of New York, New York City, N. Y. *Reports.*

Indiana Horticultural Society, Indianapolis, Ind. *Transactions.*

Indianapolis Academy of Science, Indianapolis, Ind. *Proceedings.*

International Society of Arboriculture, Connersville, Ind. "*Arboriculture.*"

Kansas Academy of Sciences, Topeka, Kansas. *Transactions.*

K. K. Zool.-Bot. Gesellschaft, Vienna, Austria. *Verhandlungen.*

K. Svenska Vetenskaps-Akademien, Stockholm, Sweden. *Handlingar Bihang afd. III.*

La Murithienne. Société Valaisanne d'Histoire Naturelle, Sion, Valais, Switzerland. *Bulletin de la Murithienne.*

Massachusetts Horticultural Society, Boston, Mass. *Transactions.*

Michigan Academy of Science, Ann Arbor, Mich. *Report.*

Michigan Horticultural Society, Lansing, Michigan. *Annual Report.*

Minnesota Horticultural Society, Minneapolis, Minn. *Transactions.*

Natural History Association of Miramichi, Chatham, New Brunswick. *Proceedings.*

Natural History Society of New Brunswick, St. John, New Brunswick. *Bulletin.*

Natural Science Association of Staten Island, New Brighton, N. Y. *Proceedings.*

Naturforschende Gesellschaft in Basel, Basel, Switzerland. *Verhandlungen.*

Naturforschende Gesellschaft in Zürich, Zürich, Switzerland. *Vierteljahrsschrift.*

Naturhistorische Gesellschaft zu Nürnberg, Nürnberg, Germany. *Abhandlungen.*

Naturwissenschaftlicher Verein zu Bremen, Bremen, Germany. *Abhandlungen.*

New Jersey State Horticultural Society, Trenton, N. J. *Proceedings.*

New York Academy of Sciences, New York City, N. Y. *Annals.*

New York Farmers, New York City, N. Y. *Proceedings.*

New York Zoölogical Society, New York City, N. Y. *Report* and *News Bulletin.*

Nova Scotian Institute of Science, Halifax, N. S. *Proceedings and Transactions.*

Pennsylvania Forestry Association, Philadelphia, Pa. "*Forest Leaves.*"

Physiographiske Forening i Christiania, Christiania, Norway. *Nyt Magazin for Naturvidenskaberne.*

Portland Society of Natural History, Portland, Me. *Proceedings.*

Rochester Academy of Sciences, Rochester, N. Y. *Proceedings.*

St. Louis Academy of Natural Sciences, St. Louis, Mo. *Transactions.*

Santa Barbara Society of Natural History, Santa Barbara, California. *Bulletin.*

Schweizerische Botanische Gesellschaft, Bern, Switzerland. *Berichte.*

Sociedad Científica Argentina, Buenos Aires, Argentine Republic. *Anales.*

Sociedad Mexicana de Historia Natural, Mexico City, Mexico. "*La Naturaleza.*"

Sociedade Broteriana, Jardim Botanico, Coimbra, Portugal. *Boletim.*

Société Botanique, Université de Gand, Ghent, Belgium. "*Dodonea.*"

Société Botanique de Copenhague, Copenhagen, Denmark. "*Botanisk Tidsskrift.*"

Société Botanique de Leide, Leyden, Holland. "*Nederlandsch Kruidkundig Archief.*"

Société Botanique du Grand Duché de Luxembourg, Luxembourg, Grand Duché de Luxembourg. *Recueil.*

Société d'Histoire Naturelle de Macon, Macon, France. *Bulletin.*

Société des Naturalistes Luxembourgeois, Luxembourg, Grand Duché de Luxembourg. "*Fauna.*"

Société des Sciences Naturelles de Saone-et-Loire, Chalon-sur-Saone, France. *Bulletin.*

Société Impériale des Naturalistes de Moscou, Moscow, Russia. *Bulletin.*

Société Linnéenne de Paris, Paris, France. *Bulletin Mensuel.*

Societe Royale de Botanique de Belgique, Brussels, Belgium. *Bulletin.*

Society for Plant Morphology and Physiology. *Publications.*

Society for the Preservation of Native Plants, Boston, Mass. *Leaflets.*

Society of American Florists, Boston, Mass. *Proceedings.*

Southern California Academy of Sciences, Los Angeles, Cal. *Bulletin.*

Texas Academy of Science, Austin, Texas. *Transactions.*

Torrey Botanical Club, New York City, N. Y. *Bulletin, Memoirs,* "*Torreya.*"

University of Wisconsin Library, Madison, Wis. *Bulletin.*

Videnskabs-Selskabet, Christiania, Norway. *Skrifter.*

Washington Academy of Sciences, Washington, D. C. *Proceedings.*

Wisconsin Academy of Arts and Sciences, Madison, Wis. *Transactions.*

Wisconsin Natural History Society, Milwaukee Public Museum, Milwaukee, Wis. *Proceedings.*

Journals.

American Agriculturist, New York City, N. Y.
American Botanist, Binghampton, N. Y.
American Florist, Chicago, Ill.
American Gardening, New York City, N. Y.
American Journal of Pharmacy, Philadelphia, Pa.
American Monthly Microscopical Journal, Washington, D. C.
Annales Mycologici, Berlin, Germany.
Botanical Gazette, Chicago, Ill.
Botaniska Notiser, Lund, Sweden.
Bulletin of Pharmacy, Detroit, Mich.
California Floriculturist, Los Angeles, Calif.
Chicago Hardwood Record, Chicago, Ill.
Country Life in America, Ithaca, N. Y.
Feuille des Jeunes Naturalistes, Paris, France.
Floral Life, Philadelphia, Pa.
Florist's Exchange, New York City, N. Y.
Gamophyllous, Plainfield, N. J.
Gardening, Chicago, Ill.
India Rubber World, New York City, N. Y.
Journal of Applied Microscopy, Rochester, N. Y.
Journal of Geography, Chicago, Ill.
Journal of Mycology, Columbus, Ohio.
Magyar Botanikai Lapok, Budapest, Hungary.
Mayflower, Floral Park, Long Island, N. Y.
Mazama, Portland, Oregon.
Meehans' Monthly, Germantown, Pa.

Muhlenbergia, Los Gatos, Calif.
Nuova Notarisia, Padua, Italy.
Ottawa Naturalist, Ottawa, Canada.
Park and Cemetery, Chicago, Ill.
Pharmaceutical Record, New York City, N. Y.
Pharmaceutical Review, Milwaukee, Wis.
Pittonia, Washington, D. C.
Plant World, Washington, D. C.
Popular Science Monthly, New York City, N. Y.
Revue Bryologique, Cahan, Athis, France.
Revue des Cultures Coloniales, Paris, France.
Revue Horticole, Paris, France.
Revue de l'Horticulture Belge et Etrangère, Ghent, Belgium.
Revue Scientifique du Bourbonnais et du Centre de la France, Moulins, France.
Rural New Yorker, New York City, N. Y.
Science, New York City, N. Y.
Vick's Illustrated Monthly Magazine, Rochester, N. Y.
West American Scientist, San Diego, Calif.
Zoe, San Diego, Calif.

Periodicals Subscribed for by the Garden.

Académie Internationale de Géographie Botanique, Le Mans, France. *Bulletin.*
Archiv der Pharmazie, Berlin, Germany.
Beiträge zur Wissenschaftlichen Botanik, Stuttgart, Germany.
Biltmore Botanical Studies, Biltmore, N. C.
Biologisches Centralblatt, Leipzig, Germany.
Biometrika, London, England.
Botanisches Centralblatt, Cassel, Germany.
Bryologist, Brooklyn, N. Y.
Bulletin du Jardin Colonial et des Jardins d'Essai des Colonies Françaises, Paris, France.
Centralblatt für Bacteriologie: *Abtheilung I.–II.*
Flora and Sylva, London, England.
Forestry and Irrigation, Washington, D. C.
Gartenflora, Munich, Germany.
Gartenkunst, Berlin, Germany.
Hoppe-Seyler's Zeitschrift für Physiologische Chemie, Strassburg, Germany.

House and Garden, Philadelphia, Pa.

Jardin Botanique de Buitenzorg, Batavia, Java. ***Annales, Icones Bogorienses.***

Journal d'Agriculture Tropicale, Paris, France.

K. K. Zool.-Bot. Gesellschaft, Vienna, Austria. ***Abhandlungen.***

La Cellule, Lièrre, France.

Le Botaniste, Poitiers, France.

Lindenia, Brussels, Belgium.

Nature, London, England.

New England Botanical Club, Boston, Mass. **"*Rhodora.*"**

Orchid Review, London, England.

Revue de Botanique Systematique et de Géographie Botanique, Asnières, France.

Royal Horticultural Society, London, England. ***Journal.***

Society for the Promotion of Agricultural Science. ***Proceedings.***

Zeitschrift für Wissenschaftliches Mikroscopie, Braunschweig, Germany.

Periodicals Subscribed for by Columbia University and Deposited at the Garden.

Allgemeine Botanische Zeitschrift, Karlsruhe, Germany.

Annales des Sciences Naturelles: Botanique, Paris, France.

Baumgarten, Jahresbericht über Pathogenen Mikroorganismen, Braunschweig, Germany.

Bibliotheca Botanica, Stuttgart, Germany.

Botanische Jahrbücher, Leipzig, Germany.

Botanische Zeitung, Leipzig, Germany.

Botanischer Jahresbericht (Just's), Leipzig, Germany.

Botanisches Centralblatt, Cassel, Germany.

Botanisches Centralblatt: Beihefte, Cassel, Germany.

Curtis' Botanical Magazine, London, England.

Deutsche Botanische Gesellschaft, Berlin, Germany. *Berichte.*

Flora, Marburg, Germany.

Garden, London, England.

Gardener's Chronicle, London, England.

Jahrbücher für Wissenschaftliche Botanik, Leipzig, Germany.

Journal de Botanique, Paris, France.

Linnean Society, London, England. *Journal: Botany*, and *Transactions: Botany.*

Malpighia, Genoa, Italy.

Monatsschrift für Kakteenkunde, Neudamm, Germany.
Osterreichische Botanische Zeitschrift, Vienna, Austria.
Revue Générale de Botanique, Paris, France.
Société Botanique de France, Paris, France. *Bulletin.*
Société Mycologique, Paris, France. *Bulletin.*
Zeitschrift für Pflanzenkrankheiten, Stuttgart, Germany.

Periodicals Received in Exchange by the Torrey Botanical Club and Deposited at the Garden.

American Naturalist, Boston, Mass.
American Philosophical Society, Philadelphia, Pa. *Transactions.*
Annals of Botany, London, England.
Boston Society of Natural History, Boston, Mass. *Proceedings.*
California Academy of Sciences, San Francisco, Calif. *Proceedings.*
Canadian Record of Science, Montreal, Canada.
Columbus Horticultural Society, Columbus, Ohio. *Journal.*
Deutsche Botanische Monatsschrift, Arnstadt, Germany.
Edinburgh Botanical Society, Edinburgh, Scotland. *Transactions.*
Hedwigia, Dresden, Germany.
Journal of Botany, London, England.
K. K. Zoologisch-Botanische Gesellschaft, Vienna, Austria. *Verhandlungen.*
Manchester Institute of Arts and Sciences, Manchester, N. H. *Nature Study.*
Minnesota Horticulturist, Minneapolis, Minn.
Natural History Laboratories of Iowa University, Iowa City, Iowa. *Bulletin.*
Naturwissenschaftlicher Verein des Regierungsbezirkes, Frankfurt a/O., Germany. *Helios.*
Pharmaceutical Archives, Milwaukee, Wis.
Pharmaceutical Review, Milwaukee, Wis.
Pittonia, Washington, D. C.
R. Istituto Botanico di Roma, Rome, Italy. *Annuario.*
Revue Mycologique, Toulouse, France.
Royal Botanic Gardens, Trinidad, W. I. *Bulletin of Miscellaneous Information.*
Royal Gardens, Kew, England. *Bulletin of Miscellaneous Information.*

Royal Microscopical Society, London, England. *Journal.*

St. Petersburg Botanical Garden, St. Petersburg, Russia. *Acta.*

Società Botanica Italiàna, Florence, Italy. *Bullettino*, *Nuovo Giornale Botanico Italiano.*

Société Botanique de Copenhague, Copenhagen, Denmark. *Botanisk Tidsskrift.*

Tōkyō Botanical Society, Tokio, Japan. *Botanical Magazine.*

REPORT OF THE HEAD GARDENER.

To the Director-in-Chief.

Sir: I have the honor to submit herewith my report as head gardener for the year 1903.

General Horticultural Operations.

For the accomplishment of this work I have had the assistance of the following force: Mr. Geo. A. Skene, second gardener, who has taken charge of its immediate direction; two foreman-gardeners, fifteen gardeners, seven apprentices, and from spring until cold weather set in an average of about eleven laborers. In addition to the above, one driver for his entire time and one during the mowing season were detailed to my department for the purposes of mowing and hauling; carts for special work have also been employed at short intervals.

Of the above force two foreman-gardeners, nine gardeners and five apprentices have been detailed to the conservatories; one gardener, one apprentice and two laborers (one having been withdrawn at the approach of cold weather) to the propagating houses; and five gardeners, one apprentice and nine laborers to the outside work. Of the outdoor force one gardener, one laborer and one apprentice took charge of the herbaceous grounds and of that portion of the pinetum in its immediate neighborhood; two gardeners and three laborers were employed in hand-mowing and raking, in the areas other than the herbaceous grounds; two laborers did the work in the fruticetum and in part of the deciduous arboretum; and one gardener and the remaining laborers constituted a movable force which was used at various points, where most needed.

Decorative Plantations.

The completion of the four rows of trees in the front approach to the museum was accomplished by the planting of the tulip trees, for which purpose places had been left at the

time of the planting of the poplars the previous fall. Twenty-six trees were required for this purpose; all but four lived, these succumbing to the drought which immediately followed their planting.

Further work in the line of decoration was also accomplished in this vicinity by the planting of groups of shrubs and conifers. Two of these groups were placed to the north of the fountain enclosure, one each side of the entrance, and one to the west of it, across the road from the fountain. In a corresponding position on the eastern side of this portion of the fountain enclosure, and to the east and west of this enclosure on the other side of the road, the planting of portions of the systematic collections of conifers was so arranged as to make effective groups at these points.

The beds in proximity to the fountain basin were planted with cannas and other decorative plants, and agaves were placed in the urns on the top of the columns of the garden fountain enclosure.

Along the roads and paths near the fountain and along those which serve to connect it with the conservatory area, and also along the roads and paths in the vicinity of the conservatories and at the south entrance, has been planted a miscellaneous assortment of trees, enhancing the beauty of the landscape effects and also insuring for the future the shade much needed along these thoroughfares. Seventy-three trees were required for this purpose. Those planted on each side of the south plaza at the conservatories, and located between the path and the carriage road, were placed at equal distances and in line, as were also those lining each side of the road at the south entrance, the formality of the surroundings requiring this treatment. The remainder were placed at irregular intervals and formality avoided.

The opening of the path paralleling the south border made apparent the necessity of closely planting the area lying between the path and the service road. The planting of the shrubs to accomplish this purpose was finished in the fall for about three quarters of the distance. Some of the shrubs

already there, and forming part of the old south border, remained as they were, while it was necessary to transplant others. About one thousand shrubs were used, derived from our own nurseries and borders, or by exchange with other institutions, or by gift. Planting continued along this line until stopped by severe cold weather.

A portion of the west border was also planted with shrubs and trees in the neighborhood of the power-house; and also a small portion which had been disturbed in the laying of the new water-main the year before. The material moved from the west border to make way for the approach for the Mosholu Parkway bridge was distributed in various places, the herbaceous plants being incorporated with other parts of the herbaceous border and the shrubs being used in the planting of the south border, already referred to.

Systematic Plantations.

Morphological Garden. Just to the north of the herbaceous grounds and in the same swale, this new feature has been inaugurated. Here are to be brought together a collection of plants illustrating the forms of stems, leaves, inflorescences and habit of growth, methods of vegetative propagation, dissemination of seeds, and many other interesting features of plant life. Placed as this collection is in the immediate neighborhood of the large collection of herbaceous plants systematically arranged, each collection will serve to enhance the interest in the other.

During the past fall thirteen beds were opened up and sixty-three species installed in them. This work will be continued in the spring, when it is planned to greatly increase the representation.

Herbaceous Grounds. Here no marked changes have been made, excepting in the area devoted to the ferns. This has been entirely replanted, rearranged and enlarged. Several new beds have been added and others enlarged. One gardener and two assistants have done all the work in this tract, including the hand-mowing and raking; they have also culti-

vated the circles around the trees in the pinetum in the immediate vicinity of this plantation.

There are now contained in the hardy herbaceous collection, including those at the nurseries, 2,948 species and varieties.

Fruticetum. The progress in constructing roads and paths here has made it possible to rearrange the shrub collection. A small beginning was made on this during the fall of 1902, and the work was resumed early in the following spring. The collection has been now entirely rearranged, and each shrub has been treated individually, sufficient room having been allowed to permit of its unhampered development in all directions. To accomplish this required moving some of the families considerably from their former position, but the sequence has been preserved so that the various families hold the same relative position to each other that they did formerly. A large collection of herbarium specimens was made during the past summer, and these, together with those previously made, are forming the basis of a present study of this collection.

Immediately following the completion of this transplanting came the drought of the early part of last summer, but by constant hand-watering during that period permanent harm was prevented, nearly all the shrubs having survived.

There are now in the shrub collection, including those at the nurseries, 665 species and varieties.

Salicetum. The collection of willows and poplars in the north meadow has been roughly cultivated during the summer by keeping a mowed circle around each one. There are in this collection twenty-eight species, represented by eighty-eight specimens.

Deciduous Arboretum. A few additions have been made here. Material, however, is accumulating in the nurseries which will considerably increase the collection when incorporated with it. We now have, including those in the nurseries, 232 species and varieties of deciduous trees.

Pinetum. The completion of roads and paths in the area set aside for the pinetum permitted of the planting during the

early summer of a large number of specimens. These were derived in part from our nurseries and borders, where they had been collected for several years back, but for the greater part by gift from Mr. Lowell M. Palmer. The only genera previously represented in the pinetum were *Pinus*, *Taxus* and *Ginkgo*. The pines occupy the eastern portion of the ridge north of the conservatories, and the westerly side of the ridge across the road to the east from this, extending nearly down to the south entrance along the easterly side of the road. A large portion of the area east of the conservatories is also reserved for them. This is the largest genus for which provision must be made, and so considerable space has been set aside for it. One hundred and twenty specimens are at present contained here, representing thirty-five species and varieties

The ginkgos extend from the termination of the pines to the south border; there are ten specimens.

The yews occupy the easterly side of the ridge forming the westerly limit of the herbaceous grounds. There are at present in place eleven species and varieties represented by eighteen specimens.

The spruces begin at the westerly border of the pine reservation and occupy the region bounded by the conservatory path-system, the road to the station and that to the Southern Boulevard. They are at present represented by sixty-four specimens illustrating twenty-five species and varieties.

To the south of the area devoted to the spruces and to the west of the conservatories are placed the firs. Forty specimens represent fourteen species and varieties.

The retinisporas are located on and at the base of the west ern portion of the south terrace of the conservatories, care being taken in the planting of the extreme western corner to offset the unusually high bank, made unavoidable by the rather sudden falling away of the surface at that point. There are eighteen species and varieties, represented by thirty-one specimens.

Not far from the entrance to the elevated railway station, in the westerly portion of the area between the service and

carriage roads, are located the thujas in fifteen species and varieties and thirty-six specimens.

To the eastward along this same area are the cedars, additional room for which is reserved in the immediate vicinity at the base of the terrace, a space on the opposite side of the southern path, and a small area to the eastward of the conservatories. Thirty-one specimens represent nineteen species and varieties.

Not far from the cedars and in the triangle to the east of them are the taxodiums, in two species and ten specimens.

The cedars of Lebanon, the larches, the Japanese cedar and *Pseudolarix* have been allotted to the crest and easterly side of the ridge to the west and north of the morphological garden. The cedar of Lebanon is represented by two species and two specimens; the Japanese cedar by one species and three specimens; the single species of *Pseudolarix* by five specimens.

The genus *Cephalotaxus* is placed just to the north of the ginkgos, and is represented by one species and three specimens.

In addition to those enumerated above, there are now in the nurseries seventy-one species and varieties which were too small to be safely placed in their permanent positions in the pinetum. They are distributed among the genera as follows:

Juniperus	14	*Picea*	10	*Thuja*	8
Retinispora	6	*Pseudotsuga*	1	*Tsuga*	7
Pinus	6	*Cupressus*	2	*Taxus*	5
Abies	7	*Chamæcyparis*	2	*Larix*	3

The pinetum collection, including those at the nurseries, represents eighteen genera and two hundred and sixteen species and varieties.

As was the case in the fruticetum, the planting of the conifers was completed about the time of the beginning of the long drought already referred to, but by hand-watering the danger was averted, so that the loss was very small.

Viticetum. This collection remains about as it was.

Conservatories.

The arrangement of the collections here installed remains essentially the same as last year. Many genera, species and varieties not hitherto represented have been added. The tree-fern collection has been notably increased, the exploration in the West Indies during the past year having added many interesting members to this graceful group. Many of the additions in other groups have also been derived from this source, either imported direct as living plants, or grown from seeds collected in the region by the expeditions which have visited it in the interests of the Garden. The conservatory collections, including those species and varieties temporarily at the propagating houses, now embrace 6,588. There are now in the conservatories 12,921 plants, distributed as follows:

House No.	1	379	House No.	8	829
	2	804		9	191
	3	440		10	741
	4	426		11	363
	5	2,144		12	1,672
	6	904		13	1,522
	7	887		14	749
				15	870

The rapid growth of the collections, both in increased size of individuals and in the greater representation of species, has made it necessary to dispose of many duplicates during the past year, but the conservatories are still too crowded, and more material must be disposed of to give the rapidly growing plants room for expansion. More space is required to accommodate the collections here installed.

In the following table will be found the number of species in some of the larger or more conspicuous groups. For the sake of comparison, the same families are selected as were chosen last year for this purpose:

Palm family		151
Cycad family		19
Cyclanthus family		12
Aroid family		208
Fern family and its allies		451
Pine-apple family		229
Banana family		37
Pandanus family		15
Orchid family		435
Succulent collection:		
Cactus family	656	
Lily family	203	
Pine-apple family	19	
Carpet-weed family, represented by the genus *Mesembryanthemum*	88	
Spurge family	54	
Milkweed family, represented mainly by the genus *Stapelia*	47	
Sunflower family	26	
Amaryllis family, represented mainly by the genus *Agave*	132	
Stonecrop family	341	
Fouquieraceae	2	
Miscellaneous	6	1,574
Temperate collections, other than ferns, orchids and succulents		1,779
Miscellaneous tropical collections, other than those specified above		1,678
		6,588

The shades made of the brown fungus-proof cloth, which were placed in houses Nos. 9, 10 and 12 in 1902, proved so satisfactory that similar shades were installed in the past year in houses Nos. 2, 3, 4, 7, 8, 11, 14 and 15. These have proved equally satisfactory. They are simple in construction and hence easily repaired by the men, and their cost little exceeds that of a single painting of the glass, the method previously adopted to secure the necessary shade. It is believed that the problem of shading has been satisfactorily solved.

Propagating Houses and Nurseries.

The usual horticultural and experimental work has been carried on here during the year. The great activity in exploring the West Indies resulted in the accession of many new plants and seeds, the greater part of which were accommodated here for a considerable time before transferal to the conservatories. Seeds to the number of 1,839 packets have been sown, and from this source, up to the present time, 5,491 specimens have been derived, with others yet too small to be potted and accessioned, while some seeds have not as yet germinated. The experimental work has called for more of the time of the men than formerly, from its increased activity; considerably more land has been allotted for this purpose than heretofore.

To accommodate the increased size of the temperate collections, which include many bulbous plants which require to be rested for a considerable portion of the time, it has been necessary to crowd the tropical collections into two houses, so that an extra house might be obtained for the temperate plants.

There are in the propagating houses at present 8,689 plants; in the nurseries there are 2,491 trees and shrubs.

Labeling, Accessioning and Herbarium.

For this work I have had the assistance of one garden aid for a part of the time and one or two apprentices. Show-labels to the number of 1,137 have been made for the conservatories, for trees 140, and for the herbaceous grounds 371, making a total of 1,648.

Accession numbers 16,868 to 19,937, inclusive, have been registered during the year, making a total of 3,070 accessions. The total number of plants obtained from all sources has been about 10,569, of which 5,491 have been derived from seed, 1,468 by gift, 1,379 by collection, 1,673 by exchange and 558 by purchase.

The work of substituting zinc data-labels in the conservatories for the old wooden ones, begun late last year, was con-

tinued until finished, so that now all plants have metal data-labels.

The herbarium of cultivated plants has been increased by 943 sheets, most of which have been mounted and incorporated. The herbarium itself has been thoroughly overhauled and placed on the Engler and Prantl sequence of families, the genera being arranged alphabetically under each family. This has put the collection in a condition for study, a work which is now going on, with especial reference to the fruticetum collections.

The work of identifying the portions of the conservatory collections still unnamed is progressing. Fleshy plants, such as orchids, cacti, etc., are given preference as fast as they flower, for herbarium material of such plants is unsatisfactory. Herbarium material of other plants is made as fast as they come into flower, and these are being worked up as opportunity offers. All the orchids which have flowered during my presence at the Garden during the past year have been identified, so that the orchid collection is now in much better shape as to names than ever before. Many interesting West Indian forms have been added to this particular family during the past year.

The following table gives the approximate number of species in each collection, and the total number, both wild and cultivated, growing within the grounds:

Conservatories	6,588
Herbaceous grounds	2,948
Fruticetum	665
Arboretum	232
Pinetum	216
Salicetum	28
Viticetum	65
Wild flora	860
	11,602

A comparison of the above with the list of last year indicates a gain in species and varieties of 941. The greatest

gains have been made in the conservatory collections and in those of the pinetum, the former with an increase of 780, and the latter with 135. As stated elsewhere, the gain in the pinetum was due largely to the extensive collection given to the Garden by Mr. Lowell M. Palmer. The enlargement in the conservatory collections is made up to a great extent of plants imported directly from the West Indies, or grown from seeds secured there, the results of the expeditions sent out by the Garden. To the palm collection several large specimens have been added by gift, which have been chronicled in the JOURNAL of the Garden from time to time.

GEORGE V. NASH,
Head Gardener.

REPORT OF THE SUPERINTENDENT OF BUILDINGS AND GROUNDS.

To the Director-in-Chief.

Sir: I have the honor to submit herewith my report for the year ending December 31, 1903.

Buildings.

1. *Museum.* All the columns under the dome of the building have been painted with a mixture of white lead and zinc. The woodwork, such as sashes and doors, has been painted one coat throughout the building.

The sills of the windows have been puttied and made watertight with waterproof cement. Plaster has been repaired where it was needed and the iron rails of stairways painted.

On the exterior, doors and window frames have been painted. Shelving has been built for storage of books in the triangular room attached to the library.

Two sinks with water-supply and drainage for waste water have been constructed on the first and second floors, enclosed in oak wood lockers which are used for the storage of janitor's supplies.

On the roof about 160 square feet of tiles have been relaid in cement, and skylights repaired, cornices and gutters soldered and painted with metallic paint.

On the second day of July the flagpole in front of the dome was struck by lightning, which broke off several feet of it.

2. *Public Conservatories.* The exterior of the whole range, and doors and frames wherever it was practicable without deranging or moving plants in the interior, have been repaired and painted during the summer months, as well as other minor repairs such as glazing; the repair of doors has required constant attention, and it would be desirable to have those at the main entrance under the dome replaced by new ones made of seasoned cypress.

3. *Propagating Houses.* The houses have been painted on the exterior and other minor repairs made where it was necessary.

4. *Stable.* The purchase of another horse made it necessary to build an additional stall, and other stalls have been refloored where needed.

A new fire hose, 50 feet in length, has been put in near the water connection. The hay crop of 1902 lasted up to November, and we have 18 tons of hay of 1903 in barracks, sufficient to last for the year. The horses are all in healthy condition. The wagons, carts and harness have been kept in good repair; the agricultural machinery and tools are kept in storage in the cellar of the conservatories for the winter; only minor repairs will be required before putting them in use.

5. *Tool House.* A part of this structure has been transformed into a blacksmith shop, for the purpose of sharpening drills, wedges, and picks for the quarry and making minor repairs to machinery, wagons, carts and tools.

6. *Power House.* The annoyance of water getting access to the subways has been almost overcome by drainage, and connecting the catch-pit with the 24-inch sewer has prevented it from overflowing the floor.

The doors, sashes, and frames have been painted inside and out, and broken glass of the skylight has been repaired.

7. *Public Comfort Station.* The public comfort station north of the Museum was totally destroyed by fire on July 17, at 11 A. M.; the details of this occurrence have been submitted in a special report of July 20.

Construction of Roads and Paths.

The path under construction at my last annual report, leading from the power house to the Manhattan Railway station, west of the service road, has been completed. It is 11 feet in width and about 340 feet in length; the edges were regulated, drained and sodded.

A path from the Manhattan Railway station, leading to the south gate along the southerly boundary line of the Gar-

den, 1,830 feet in length and 15 feet in width, with Telford foundation, has been constructed, its north edge regulated, drained and planted, and both edges sodded; it was necessary to fill about 1,500 cubic yards between the south gate and the highest point, and to quarry about 375 cubic yards of rock; the path was opened to the public in October.

Telford foundation has been laid for a path to connect the steps in project, southeast of the conservatories, with other paths in a southeasterly direction.

Three paths about 400 feet in length and 11 feet wide have been completed from a point east of the conservatories to the south gate north of the service road. The path south of the upper lake where Telford foundation was laid in 1902 has been completed. We have completed and opened to the public in all 5,500 running feet of path during the year.

The road leading to the new bridge near the northern boundary line of the Garden was graded, and Telford foundation laid, to within 300 feet of the bridge.

Grading and Sodding.

A large area in front and east of the museum building and south of the road east of the drinking fountain was regulated, sodded, sown and brought into lawn.

The entire top of the terrace surrounding the conservatories, about 102,000 square feet, was spaded, plowed, sown and path-edges sodded. The nine squares in front of the conservatories, comprising 42,500 square feet, have been topsoiled, regulated, edges sodded and prepared for planting.

An area of about 25,000 square feet southeast of the conservatories near the south gate have been regulated, topsoiled and sown.

The slope between the driveway and path west of the conservatories, comprising about 20,000 square feet, has been regulated, sodded and sown. The terrace slope east of the conservatories, 300 feet in length and 5 feet in elevation, was regulated, topsoiled and sodded, and other small areas were regulated and sown or sodded.

Drainage and Sewerage.

The work to continue the 24-inch sewer which was completed from Webster Avenue to the N. Y. C. & H. R. R. R. in 1902, was taken up in December, 1902, and 180 feet of 24-inch pipe laid parallel with the railroad past the power house to a manhole, and thence 170 feet of 15-inch pipe in an easterly direction and connected with the 15-inch pipe laid by the Devlin Company; it became necessary as a part of this work to build a manhole east of the railroad bridge 28 feet in depth. Drain and sewer pipes from the power house were laid and connected with this 24-inch sewer.

New catch-basins were constructed wherever found necessary for the drainage of the grounds, and 740 feet of 6-inch and 8-inch pipe laid to connect them with the main sewer and other drains.

A drain was constructed partly of 24-inch pipe and partly of stone from the outlet of the lake near the south end of the herbaceous grounds, to the border of the Garden, and connected with a stone drain rebuilt by the Park Department; its surrounding areas were regulated and topsoiled for plantations.

The drain from the cellar of the museum building to the upper lake is about half completed; work upon it is in progress.

Ground was broken to build an 8-inch sewer to connect the drainage of the stable with a main sewer, 500 feet north of the driveway on the east side of the Garden.

Water Supply.

A line of 480 feet of 1-inch supply pipe was laid temporarily on the surface of the ground along the service road from the propagating houses to the nurseries.

To the extension of the herbaceous garden north of the new road, there was laid and connected 464 feet of 1-inch pipe with 6 taps for hose and sprinklers. A temporary watering station for horses has been established on the road along the east side of the Bronx River.

Quarry.

About 1,400 cubic feet of rock was quarried east of the conservatories, and 900 cubic yards at the curve of the path, north of road, near the south gate; the stone was used for Telford foundations for paths and the surplus was hauled to the road under construction to connect Mosholu Parkway with the garden driveways. A part of the rock in the rear of the museum building has been excavated.

Garden and Drinking Fountains.

The marble garden and drinking fountains on the driveway south of the museum were put into commission early in June. The drinking fountain was equipped with neat copper cups fastened to the fountain by bronze chains.

Care of the Grounds.

A fence about 700 feet in length and 4 feet high was built from the east pier of the south gate, easterly along the boundary line of the reservation, partly of red cedar and partly of cedar posts and galvanized wire, with a gateway where the path of the garden connects with the path built by the park department leading to Pelham Avenue.

We have built five garden benches of red cedar and placed them under trees along paths; they were much appreciated by the visitors, but it became necessary to detail a man daily to pick up rubbish scattered about them.

The drainage-basins have been inspected and cleaned out after rain-storms, where it was found necessary, and the drainage of the grounds in general is satisfactory.

For patrol duty on Sundays and holidays during the summer months three additional guards, selected from the Garden employees, have been detailed, but this number appears to be insufficient for the coming season, owing to the immense increase in the number of visitors; one guard is needed during afternoons and evenings at every gate of the Garden.

The woodland has been patrolled on Sundays and holidays by the regular guards, and by two men daily up to 8 P. M. during the summer months.

An explosion of a box 4 x 4 feet in diameter, placed in the woods about 700 feet east of the museum building, in which dynamite was stored for the use of the quarry, took place on the 18th day of December at 8.20 A. M. The concussion broke 248 lights of glass at the museum building, 83 small and 31 double thick and plate-glass, lights of different sizes at the conservatories, 14 lights in dwellings on Webster Avenue and surroundings, and 59 lights at the buildings of St. John's College. Fortunately no injury of life is to be reported.

Respectfully submitted,

F. A. SCHILLING,

Superintendent of Buildings and Grounds.

SCHEDULE OF EXPENDITURES DURING 1903, UNDER APPROPRIATIONS MADE BY THE BOARD OF MANAGERS.

1. City Maintenance Account		$70,000.00
Salaries and Labor.		
Appropriated	54,574.39	
Expended	54,574.39	
Supplies and Repairs.		
Appropriated	15,425.61	
Expended	15,425.61	
Total Expended		70,000.00
2. Construction and Equipment		33,380.38
Salaries and Labor.		
Appropriated	25,362.11	
Expended	25,362.11	
Sundry Expenses.		
Appropriated	8,018.27	
Expended	8,018.27	
Total Expended		33,380.38
3. Garden Accounts.		
Museums and Herbarium.		
Appropriated		2,600.00
Expended		2,598.83
Balance		1.17
Library.		
Appropriated	2,100.00	
Refund on Expressage overpaid	8.23	2,108.23
Expended		2,106.00
Balance		2.23
Laboratories.		
Appropriated		1,200.00
Expended		1,197.39
Balance		2.61

Exploration and Collecting.

Appropriated	1,500.00	
Transferred from Horticultural Prizes	235.00	
Transferred from Investigations at other Gardens and Museums	195.00	
Transferred from Resident Research Scholarships	450.00	
Refunds, Unexpended Balances	94.86	2,474.86
Expended		2,466.73
Balance		8.13

Lectures.

Appropriated		400.00
Expended		388.10
Balance		11.90

Horticultural Prizes.

Appropriated		500.00
Expended	265.00	
Transferred to Exploration and Collecting	235.00	500.00

Investigations at other Gardens and Museums.

Appropriated		1,000.00
Expended	800.15	
Transferred to Exploration and Collecting	195.00	995.15
Balance		4.85

Resident Research Scholarships.

Appropriated		1,200.00
Expended	700.00	
Transferred to Exploration to the Philippine Islands	50.00	
Transferred to Exploration and Collecting	450.00	1,200.00

Editorial Assistance.

Appropriated		600.00
Expended		600.00

Contingent Fund.

Appropriated	2,200.00	
Refunds, Expressage overpaid	1.05	2,201.05
Expended		2,200.83
Balance		.22

Stable Equipment.

Appropriated	100.00	
Transferred from Circulars for Membership	250.00	350.00
Expended		349.48
Balance		.52

Purchase of Plants.

Appropriated	1,000.00	
Refund, Expressage on plants	7.38	1,007.38
Expended		998.03
Balance		9.35

Circulars for Membership.

Appropriated		1,000.00
Expended	738.25	
Transferred to Stable Equipment	250.00	988.25
Balance		11.75

Landscape Engineering.

Appropriated		720.00
Expended		720.00

Insurance.

Appropriated		400.00
Expended		396.60
Balance		3.40

Special Assistance.

Appropriated		675.00
Expended		659.70
Balance		15.30

Grading, Drainage and Water Supply.

Appropriated		1,675.00
Expended		1,662.95
Balance		12.05

Special Appropriation for Exploration to the Philippine Islands.

Appropriated	500.00	
Transferred from Resident Research Scholarships	50.00	550.00
Expended		538.24
Balance		11.76

Publications (Income of Lydig Fund).

Appropriated		2,400.00
Expended		2,231.10
Balance		168.90

Preservation of Native Plants (Income of Stokes Fund).

Appropriated		120.00
Expended		92.96
Balance		27.04

Aid for Students' Research (Income of Students' Research Fund).

Appropriated		100.00
Balance		100.00
Total Appropriated for Garden Accounts...	21,990.00	
Refunds	111.52	22,101.52
Total Expended for Garden Accounts		21,710.34
Balance		391.18

4. Special Garden Accounts.

Conservatory Fund.

Subscribed 1900	2,110.00	
Subscribed 1901	25.00	
Refund — Balance on Draft	15.27	
Subscribed 1902	486.55	
Refund — Unexpended Balance	9.70	
Subscribed 1903	200.00	
Sale of Duplicate Palms	100.00	
Sale of Plants	78.00	3,024.52
Expended 1900	710.44	
Expended 1901	1,437.42	
Expended 1902	404.41	
Expended 1903	447.66	2,999.93
Balance		24.59

Museum and Herbarium Fund.

Subscribed 1901	1,800.00	
Subscribed 1902	655.00	
Refund (Advance Charges on Specimens, account of R. S. Williams)	131.09	

Subscribed 1903..................................	1,405.00	
Sale of Specimens..................................	29.50	4,020.59
Expended 1901..................................	1,546.19	
Expended 1902..................................	1,024.96	
Expended 1903..................................	1,437.63	4,008.78
Balance..................................		11.81

Exploration Fund.

Subscribed, 1901..................................	2,050.00	
Refund — Balance on Drafts..................	87.59	
Subscribed, 1902..................................	2,130.00	
Refund — Unexpended Balance..............	180.56	
Subscribed, 1903..................................	1,565.00	
Refunds — Unexpended Balances............	275.11	6,288.26
Expended, 1901..................................	2,130.95	
Expended, 1902..................................	1,258.32	
Expended, 1903..................................	2,880.72	6,269.99
Balance..................................		18.27

Special Book Fund.

Subscribed, 1899..................................	4,950.00	
Subscribed, 1901..................................	1,825.00	
Subscribed, 1902..................................	2,265.00	
Subscribed, 1903..................................	1,315.00	
Special Contribution from Mr. Andrew Carnegie..................................	1,997.88	
Sale of Books..................................	59.60	
Refund — Balance on Drafts..................	20.93	12,433.41
Expended, 1899..................................	1,916.65	
Expended, 1900..................................	2,395.28	
Expended, 1901..................................	2,463.02	
Expended, 1902..................................	2,256.25	
Expended, 1903..................................	3,397.75	12,428.95
Balance..................................		4.46
Total Expenditures from Funds of the Garden..................................		29,874.10

WALTER S. GROESBECK,
Accountant.

NEW YORK, January 11, 1904.

REPORT OF THE SCIENTIFIC DIRECTORS.

To the Board of Managers, New York Botanical Garden.

Gentlemen: The Scientific Directors have held three meetings during the past year, on January 13, on October 20, and on December 17. The Board has been increased in accordance with your action, and added strength has thus been given it by the election of Mr. C. F. Cox and Professor F. S. Lee.

The scientific work in progress at the Garden has been carried on with unusual energy. The increased number of persons who come to us for carrying out special lines of work attests the appreciation in which we are held by the botanical public of this country, and our standing among the great botanical centers of the world is already recognized by botanists in foreign lands.

The past year has been notable in the extent of botanical exploration carried on in the American tropics, and the policy of sending trained botanists to secure material for museum and herbarium has been amply justified by the results. From subtropical Florida to the Leeward Islands explorers have been bringing together material, so that our collections from these regions are becoming enormous, and with them our knowledge of the distribution and extent of our tropical flora is becoming more and more accurate and complete.

Not less important have been the additions to our collections and library by purchase, made possible by extensive gifts from members of your body.

A most important step has been taken in the establishment of a tropical laboratory in Jamaica under our control. This has long been a dream of American botanists, and its speedy realization may be regarded as a direct outcome of our exploration in the tropics and will be not only a material aid to all the interests of the Garden and its development, but likewise a boon to American botany and American botanists in general.

Plans for the better illustration of North American plants are before the Board and it is hoped that we may be able in the near future to present something definite for your consideration.

The scientific papers published by the Garden during the year have been noteworthy. A second volume of the MEMOIRS, by Dr. MacDougal, and a series of papers included in the BULLETIN have attracted particular attention. Although not a distinctive Garden publication, the issue of the Flora of the Southeastern States by Dr. Small, of the Garden staff, during the year, marks the completion of a monumental work.

One appointment has been made by the Board, that of Mr. J. A. Shafer as Custodian of the Museum.

The outlook for scientific work at the Garden could scarcely be more promising.

Respectfully submitted,

LUCIEN M. UNDERWOOD,

Chairman.

JANUARY 7, 1904.

REPORT OF THE COMMITTEE ON PATRONS, FELLOWS AND MEMBERS.

To the Board of Managers of the New York Botanical Garden.

Gentlemen: The number of new members who have qualified during the past year is 102. The total number of annual members is now 936.

Of these 22 are in arrears for dues for 1903, 10 are in arrears for 1902 and 1903, and 7 are in arrears for 1901, 1902 and 1903.

Annual dues have been collected to the amount of $9,110.00, which has been transmitted to the Treasurer as received.

Seventeen persons have qualified as life members by the payment of $100.00 each. These sums have been transmitted to the Treasurer for credit to the Endowment Fund.

A complete list of Patrons, Fellows for Life, Life Members and Annual Members to date is herewith submitted.

New York, January 11, 1904.

Patrons.

Hon. Addison Brown,
Andrew Carnegie,
Mrs. Geo. Whitfield Collard,
Columbia University,
* James M. Constable,
* Hon. Chas. P. Daly,
* Wm. E. Dodge,
Geo. J. Gould,
Miss Helen M. Gould,
Mrs. Esther Herrman,
John S. Kennedy,
D. O. Mills,
J. Pierpont Morgan,
* Oswald Ottendorfer,
John D. Rockefeller,
William Rockefeller,
* Wm. C. Schermerhorn,
Jas. A. Scrymser,
Samuel Sloan,
* Cornelius Vanderbilt,
Mrs. Antoinette Eno Wood.

Fellows for Life.

Morris K. Jesup,
John Innes Kane,
Hon. Seth Low,
Miss Caroline Phelps Stokes,
Miss Olivia E. Phelps Stokes,
Samuel Thorne,
Tiffany & Co.,
H. C. von Post.

* Deceased.

LIFE MEMBERS.

Edward D. Adams,
Dr. Felix Adler,
A. G. Agnew,
Mrs. James Herrman Aldrich,
Richard H. Allen,
Constant A. Andrews,
J. Sherlock Andrews,
Wm. A. Anthony,
Mrs. Hugh D. Auchincloss,
Samuel P. Avery,
Samuel P. Avery, Jr.,
Samuel D. Babcock,
Geo. V. N. Baldwin,
Dr. John Hendley Barnhart,
Gustav Baumann,
Samuel R. Betts,
Miss Elizabeth Billings,
Mrs. Wm. T. Blodgett,
J. O. Bloss,
George Blumenthal,
George C. Boldt,
G. F. Bonner,
Geo. S. Bowdoin,
J. Hull Browning,
Miss Matilda W. Bruce,
Joseph Bushnell,
Thomas M. Carnegie,
Frank R. Chambers,
Hugh J. Chisholm,
Hugh J. Chisholm, Jr.,
E. Dwight Church,
Geo. C. Clark,
Banyer Clarkson,
Wm. F. Cochran,
William Colgate,
Miss Georgette T. A. Collier,
Mrs. William Combe,
W. E. Conner,
Wm. L. Conyngham,
Theodore Cooper,
Zenas Crane,
Melville C. Day,
Miss Julia L. Delafield,
Maturin L. Delafield, Jr.,
Anthony Dey,
James Douglass,
Miss Josephine W. Drexel,
Miss Ethel DuBois,
Miss Katharine DuBois,
Wm. A. DuBois,
Mrs. John Dwight,
Thomas Dwyer,
Newbold Edgar,
George Ehret,
David L. Einstein,
Ambrose K. Ely,
Amos F. Eno,
Edward J. Farrell,
Andrew Fletcher,
Chas. R. Flint,
James B. Ford,
Mrs. Theodore Kane Gibbs,
James J. Goodwin,
J. B. M. Grosvenor,
Daniel Guggenheimer,
Bernard G. Gunther,
Franklin L. Gunther,
Frederic R. Halsey,
Chas. J. Harrah,
Dr. Louis Haupt,
H. O. Havemeyer,
R. Somers Hayes,
James J. Higginson,
George B. Hopkins,
Samuel N. Hoyt,
Gen. Thomas H. Hubbard,
Archer M. Huntington,
Frank D. Hurtt,

Adrian Iselin,
Theo. F. Jackson,
Dr. Walter B. James,
Dr. E. G. Janeway,
Miss Annie B. Jennings,
Walter R. T. Jones,
Eugene Kelly, Jr.
Nathaniel T. Kidder,
William M. Kingsland,
H. R. Kunhardt,
W. B. Kunhardt,
Charles Lanier,
W. V. Lawrence,
Meyer H. Lehman,
Mrs. George Lewis,
Joseph Loth,
David Lydig,
Wm. H. Macy, Jr.,
Mrs. William H. Macy, Jr.,
Alexander Maitland,
Dr. Francis H. Markoe,
Louis Marshall,
Edgar L. Marston,
Bradley Martin,
Dr. George N. Miller,
A. G. Mills,
Roland G. Mitchell,
John G. Moore,
A. Lanfear Norrie,
Gordon Norrie,
George M. Olcott,
Mrs. Chas. Tyler Olmsted,
Wm. Church Osborn,
Lowell M. Palmer,
Henry Parish,
Geo. Foster Peabody,
Wm. Hall Penfold,
Geo. W. Perkins,
W. H. Perkins,
Mrs. Henry C. Potter,
James Tolman Pyle,
M. Taylor Pyne,
Geo. W. Quintard,
J. C. Rodgers,
H. H. Rogers,
Jacob Rubino,
Wm. R. Sands,
Reginald H. Sayre,
Edward C. Schaefer,
Jacob H. Schiff,
Mortimer L. Schiff,
Grant B. Schley,
Mrs. I. Blair Scribner,
Isaac N. Seligman,
Geo. Sherman,
William D. Sloane,
James Speyer,
Francis L. Stetson,
Anson Phelps Stokes,
Miss Ellen J. Stone,
Albert Tag,
Charles G. Thompson,
Robert M. Thompson,
Miss Phebe Anna Thorne,
William Thorne,
William Stewart Tod,
Spencer Trask,
Miss Susan Travers,
Miss Anna Murray Vail,
F. T. Van Beuren,
Dr. Henry Freeman Walker,
F. N. Warburg,
John I. Waterbury,
Miss Emily A. Watson,
S. D. Webb,
Dr. W. Seward Webb,
Mrs. Joseph M. White,
Miss Violetta S. White,
John D. Wing,
Charles T. Yerkes.

ANNUAL MEMBERS.

Dr. Robert Abbe,
Fritz Achelis,
Ernest R. Ackerman,
Ernest Kempton Adams,
Samuel Adams,
Mrs. Cornelius R. Agnew,
R. Percy Alden,
Jas. A. Alexander,
John E. Alexandre,
J. H. Alexandre,
C. L. Allen,
Wm. C. Alpers,
Bernard G. Amend,
G. Amsinck,
John A. Amundson,
J. M. Andreini,
A. B. Ansbacher,
John D. Archbold,
George A. Archer,
Francis J. Arend,
Mrs. H. O. Armour,
Dr. S. T. Armstrong,
Dr. Edmund S. F. Arnold,
Francis B. Arnold,
Col. John Jacob Astor,
Theo. Aub,
Hugh D. Auchincloss,
John W. Auchincloss,
Marshal L. Bacon,
Miss H. B. Bailey,
James A. Bailey,
Frederic Baker,
Stephen Baker,
Frederick H. Baldwin,
Robert F. Ballantine,
Theodore M. Banta,
Amzi Lorenzo Barber,
Henry I. Barbey,
E. W. Barnes,
John S. Barnes,
Chas. T. Barney,
William Barr,
George D. Barron,
E. W. Bass,
Chas. Batchelor,
Mrs. N. E. Baylies,
Alfred N. Beadleston,
Wm. R. Beal,
Dr. C. Adelbert Becker,
Gerard Beekman,
M. H. Beers,
Dennistonn M. Bell,
August Belmont,
Perry Belmont,
James H. Benedict,
L. L. Benedict,
M. W. Benjamin,
Jno. R. Bennett,
Frank Sherman Benson,
Gustav Bernheim,
Mrs. Adolph Bernheimer,
Chas. L. Bernheimer,
Simon E. Bernheimer,
Philip Berolzheimer,
Edward J. Berwind,
Henry Beste,
Albert S. Bickmore,
Eugene P. Bicknell,
Mrs. Sylvan Bier,
L. Horatio Biglow,
Isaac Bijur,
W. H. Birchall,
James C. Bishop,
Karl T. F. Bitter,
Geo. Blagden,
Mrs. D. C. Blair,
Mrs. Birdseye Blakeman,
Samuel Blatchford,

Mrs. S. A. Blatchford,
Cornelius N. Bliss,
Ernest C. Bliss,
E. W. Bliss,
Jno. H. Bloodgood,
Lyman G. Bloomingdale,
Mrs. Edward C. Bodman,
Henry W. Boettger,
Edward C. Bogert,
Frank S. Bond,
Wm. E. Bond,
Hon. H. W. Bookstaver,
Simon Borg,
Frederick G. Bourne,
Temple Bowdoin,
John M. Bowers,
Anthony N. Brady,
James B. Brady,
E. T. Bragaw,
Michael Brennan,
Victor D. Brenner,
Miss Cornelia G. Brett,
Mrs. Benjamin Brewster,
Elbert A. Brinckerhoff,
Jno. I. D. Bristol,
Mrs. Harriet Lord Britton,
Mrs. Kate M. Brookfield,
Edwin H. Brown,
John Crosby Brown,
M. Bayard Brown,
Robert I. Brown,
W. L. Brown,
W. P. Brown,
F. W. Bruggerhof,
H. B. Brundrett,
Miss Mary T. Bryce,
Mrs. William Bryce,
William Bryce, Jr.,
W. Buchanan,
Albert Buchman,
James Buckhout,
H. C. Bumpus,
Edward G. Burgess,
Miss Helen C. Butler,
Wm. H. Butler,
Mrs. Daniel Butterfield,
John L. Cadwalader,
H. A. Caesar,
S. R. Callaway,
Albert Calman,
Henry L. Calman,
W. L. Cameron,
H. H. Cammann,
Henry L. Cammann,
John Campbell,
Richard A. Canfield,
H. W. Cannon,
Mrs. Miles B. Carpenter,
James C. Carter,
Walter S. Carter,
H. T. Cary,
John W. Castree,
John H. Caswell,
John R. Caswell,
Dr. W. H. Caswell,
Robert Caterson,
Miss Jennie R. Cathcart,
Prof. J. McK. Cattell,
J. E. Childs,
H. P. Chilton,
B. Ogden Chisolm,
Geo. E. Chisolm,
Mrs. Wm. E. Chisolm,
Jared Chittenden,
Wm. G. Choate,
W. F. Chrystie,
Miss Helen L. Chubb,
Theodore W. Church,
John Claflin,
D. Crawford Clark,

J. Mitchell Clark,
W. A. Clark,
Wm. N. Clark,
C. C. Clarke,
Wm. P. Clyde,
Dr. Wm. J. Coates,
John W. Cochrane,
Miss Mary F. Cockcroft,
Hon. W. Bourke Cockran,
C. A. Coffin,
Edmund Coffin,
E. W. Coggeshall,
Samuel M. Cohen,
N. A. Colburn,
Mrs. James B. Colgate,
P. F. Collier,
F. Collingwood,
Miss Ellen Collins,
Miss Mary Compton,
T. G. Condon,
Henry C. Conger,
Roland R. Conklin,
C. T. Cook,
Mrs. C. T. Cook,
Henry H. Cook,
Chas. W. Cooper,
Hon. Edward Cooper,
Mrs. Austin Corbin,
G. M. Corning,
Mrs. Charles Henry Coster,
Miss Ellen Cotheal,
John Cotter,
Chas. J. Coulter,
Clarkson Cowl,
Geo. F. Crane,
Jonathan H. Crane,
Mrs. Jonathan H. Crane,
Mrs. Agnes H. Cravath,
Robert L. Crawford,
Dr. W. H. Crawford,
H. G. Crickmore,
John D. Crimmins,
Geo. A. Crocker,
Frederic Cromwell,
Jas. W. Cromwell,
Chas. H. Cronin,
Edwin A. Cruikshank,
Chas. Curie,
Chas. B. Curtis,
R. Fulton Cutting,
W. Bayard Cutting,
C. H. Dale,
Henry Dalley,
Wm. B. Dana,
Geo. H. Daniels,
Ira Davenport,
J. Clarence Davies,
Julien T. Davies,
Wm. Gilbert Davies,
Clarence S. Day,
Mrs. Henry Mills Day,
E. J. de Coppet,
H. de Coppet,
Richard Deeves,
Robert W. deForest,
Mrs. Courtnay DeKalb,
B. F. DeKlyn,
Dr. D. Bryson Delavan,
Wm. C. Demorest,
Charles de Rham,
Theo. L. DeVinne,
F. W. Devoe,
Henry Dexter,
W. B. Dickerman,
Chas. D. Dickey,
Geo. H. Diehl,
Chas. F. Dieterich,
Miss Mary A. Dill,
Mrs. Henry F. Dimock,
Rev. Morgan Dix,

Cleveland H. Dodge,
D. Stuart Dodge,
Geo. E. Dodge,
Miss Grace H. Dodge,
Norman W. Dodge,
Mrs. Wm. E. Dodge, Jr.,
Peter Doelger,
C. W. Doherty,
L. F. Dommerich,
Mrs. Henry Dormitzer,
Henry Dorscher,
Mrs. George Wm. Douglas,
Alfred Douglass,
R. D. Douglass,
Mrs. David Dows,
Tracy Dows,
John J. Drake,
B. Ferdinand Drakenfeld,
Mrs. Henry Draper,
H. R. Drew,
Isaac W. Drummond,
Matthew B. DuBois,
Dr. Edward K. Dunham.
George H. Dunham,
E. B. Dunne,
James Dunne,
S. Whitney Dunscomb, Jr.,
H. A. Dupont,
John S. Durand,
J. B. Dutcher,
John Dwight,
D. Edgar,
Miss Laura Jay Edwards,
Edward Ehrlich,
Henry G. Eilsheimus,
August Eimer,
Emanuel Einstein,
Mrs. Matilda A. Elder,
Lewis A. Eldridge,
Roswell Eldridge,
Geo. W. Ellis,
John W. Ellis,
W. H. Ellis,
J. M. Ellsworth,
James W. Ellsworth,
Wm. Ellsworth,
John J. Emery,
C. Temple Emmet,
Robert Temple Emmet,
Robert Endicott,
A. Engler,
John C. Eno,
R. Erbsloh,
Arthur F. Estabrook,
Louis Ettlinger,
Richard Evans,
H. C. Fahnestock,
Chas. S. Fairchild,
Samuel W. Fairchild,
Geo. W. Fanning,
Jas. C. Fargo,
John Armstrong Faust,
Mrs. Farquhar Ferguson,
W. B. Osgood Field,
Wm. H. Fisher,
E. W. Fitch,
Wm. Louis Fitzgerald,
Isaac D. Fletcher,
Miss Helena Flint,
A. R. Flower,
Edw. W. Foster,
Scott Foster,
Henry E. Frankenberg,
Werner V. Frankenberg,
A. S. Frissell,
H. T. Frothingham,
W. F. Gade,
Geo. F. Gantz,
John A. Garver,
Joseph E. Gay,

Mrs. Martha F. Gay,
Mrs. James Gayley,
Frederick Gebhard,
Mrs. Walter Geer,
S. J. Geoghegan,
Thos. Ghee,
John J. Gibbons,
Frederick Gibbs,
Mrs. Hervey de Blois Gibson,
R. W. Gibson,
J. Waldron Gillespie,
Frederic N. Goddard,
Chas. H. Godfrey,
Mrs. Edwin L. Godkin,
Samuel Goodman,
Rev. Francis Goodwin,
Miss Theodora Gordon,
Chas. Gotthelf,
Charles A. Gould,
Edwin Gould,
Hon. Wm. R. Grace,
Robert D. Graham,
W. H. Granbery,
Henry Graves,
John Clinton Gray,
Ernest F. Greeff,
Edward C. Gregory,
John Greenough,
Isaac J. Greenwood,
Rev. David H. Greer,
Daniel J. Griffith,
E. Morgan Grinnell,
Hon. George J. Grossmann,
William Guggenheim,
W. C. Gulliver,
Miss Delia L. Gurnee,
W. S. Gurnee, Jr.,
Dr. Alexander Hadden,
John A. Hadden,
John A. Hadden, Jr.
J. and M. Haffen,
James D. Hague,
Hon. Ernest Hall,
Miss Laura P. Halsted,
Wm. Hamann,
Miss Katherine L. Hamersley,
Louis Gordon Hamersley,
Miss Adelaide Hamilton.
Chas. T. Harbeck,
Anson W. Hard,
J. Montgomery Hare,
E. S. Harkness,
E. H. Harriman,
S. W. Harriot,
Alan C. Harris,
Wm. Hamilton Harris,
Miss Rebecca Harvey,
Harold Hasbrouck,
Jacob Hasslacher,
J. C. Havemeyer,
T. A. Havemeyer,
G. G. Haven,
J. Woodward Haven,
E. Hawley,
Frederick W. Haynes,
Arthur H. Hearn,
Wm. W. Heaton,
John G. Heckscher,
L. A. Heinsheimer,
Max Heller,
Homer Heminway,
Miss Olivia P. Heminway,
Chas. R. Henderson,
Chas. Henderson & Son,
Edmund Hendricks,
Harmon W. Hendricks,
Samuel Henshaw,
Selmar Hess,
Mrs. Daniel M. Hildreth,
Geo. R. Hill,

George D. Hilyard,
Walter Hinchman,
Wm. K. Hinman,
Dr. John H. Hinton,
B. Hochschild,
George F. Hodgmann,
Alfred G. Hoe,
Richard M. Hoe,
Mrs. Richard M. Hoe,
Mrs. Robert Hoe,
John Swift Holbrook,
E. B. Holden,
E. R. Holden,
Miss Virginia Hollins,
Henry Holt,
Isaac A. Hopper,
William W. Hoppin,
Frederick B. House,
Wm. P. Howe,
Alfred M. Hoyt,
Gerald L. Hoyt,
Alex. C. Humphreys,
Miss Mary D. Humphreys,
Mrs. C. P. Huntington,
Mrs. Robert P. Huntington,
Adolph G. Hupfel,
Frank Hustace,
John S. Huyler,
Clarence M. Hyde,
Frederick E. Hyde, Jr.,
Henry Iden, Jr.,
Mrs. Samuel Inslee,
John B. Ireland,
Adrian Iselin, Jr.,
C. Oliver Iselin,
Miss Georgine Iselin,
William E. Iselin,
Miss Flora Isham,
Samuel Isham,
Wm. B. Isham,
Frederic W. Jackson,
Dr. Abram Jacobi,
A. C. James,
D. Willis James,
Dr. Robert C. James,
O. G. Jennings,
Walter Jennings,
Adrian H. Joline,
Mrs. John D. Jones,
Jos. L. Kahle,
O. H. Kahn,
Miss Louise L. Kane,
S. Nicholson Kane,
Mrs. H. F. Kean,
Mrs. Chas. Kellogg.
Thos. H. Kelly,
Prof. J. F. Kemp,
H. Van Rensselaer Kennedy,
Mrs. Elizabeth C. Kenyon,
Rudolph Keppler,
Mrs. Catherine L. Kernochan,
John B. Kerr,
Geo. A. Kessler,
A. P. Ketchum,
W. Keuffel,
Wm. Kevan,
Samuel K. Keyser,
S. E. Kilner,
Alfred R. Kimball,
David H. King, Jr.
Le Roy King,
William F. King,
Gustave E. Kissel,
A. Julian Klar,
Herman Knapp,
Chas. Kohlman,
Wm. Krafft,
H. C. Kudlick,
Julius G. Kugelman,
Percival Kühne,

Adolf Kuttroff,
William M. Laffan,
Rev. Anthony Lammel,
Francis G. Landon,
Woodbury Langdon,
Woodbury G. Langdon,
J. Langeloth,
Dr. G. Langmann,
Lewis H. Lapham,
Walter W. Law,
John Burling Lawrence,
Mrs. Lydia G. Lawrence,
Richard H. Lawrence,
Mrs. Samuel Lawrence,
J. D. Layng,
Charles N. Lee,
Prof. Frederic S. Lee,
Mrs. Frederic S. Lee,
Marshall E. Lefferts,
Wm. H. Lefferts,
Emanuel Lehman,
Lemcke & Buechner,
Alfred Le Roy,
Edward A. Le Roy, Jr.
Arthur L. Lesher,
Dr. W. Monae Lesser,
Wm. H. Leupp,
Emil Levi,
Julius Levine,
Emanuel Levy,
Mrs. John V. B. Lewis,
Albert Lewisohn,
Miss Alice Lewisohn,
Philip Lewisohn,
O. B. Libbey,
Lowell Lincoln,
Frederick J. Lisman,
Wm. S. Livingston,
Wm. C. Lobenstine,
Luke A. Lockwood,
Williston B. Lockwood,
James Loeb,
Prof. Morris Loeb,
S. Loeb,
Charles Loeber,
Walter S. Logan,
Henry Lomb,
Franklin B. Lord,
P. Lorillard, Jr.,
Bernard Loth,
R. P. Lounsberry,
C Adolphe Low,
Miss Carlotta R. Lowell,
Mrs. Charles R. Lowell,
Thomas Lowry,
Charles H. Ludington,
August Lueder.
Walther Luttgen,
Mrs. Alida McAlan,
C. W. McAlpin,
Geo. L. McAlpin,
Wm. W. McAlpin,
John A. McCall,
Mrs. W. H. McCord,
Rev. Haslett McKim,
Geo. Wm. McLanahan,
James McLean,
Geo. R. MacDougall,
J. W. Mack,
Clarence H. Mackay,
D. E. MacKenzie,
Malcolm MacMartin,
Mrs. Charles A. Macy, Jr.,
V. Everit Macy,
F. Robert Mager,
J. H. Maghee,
Jacob Mahler,
Chas. Mallory,
Howard Mansfield,
Thos. L. Manson,

Miss Delia W. Marble,
Theophilus M. Marc,
A. Marcus,
Jacob Mark,
Dr. J. W. Markoe,
Henry S. Marlor,
C. P. Marsh,
Chas. H. Marshall,
Edwin S. Marston,
Mrs. E. Howard Martin,
W. R. H. Martin,
Francis T. Maxwell,
Robert Maxwell,
David Mayer,
Harry Mayer,
Mrs. Emma Mehler,
Herman A. Metz,
Dr. Alfred Meyer,
Edwin O. Meyer,
Harry J. Meyer,
J. Meyer,
Thos. C. Meyer,
John Miles,
Geo. M. Miller,
Jacob F. Miller,
S. M. Milliken,
W. McMaster Mills,
Arthur M. Mitchell,
John Murray Mitchell,
Peter Moller,
Alphonse Montant,
G. L. Montgomery,
Chas. A. Moore, Jr.,
Wm. H. Helme Moore,
Mrs. Daniel Moran,
Miss Annie T. Morgan,
Miss C. L. Morgan,
Edward Morgan,
E. D. Morgan,
Geo. H. Morgan,
A. H. Morris,
A. Newbold Morris,
Mrs. A. Newbold Morris,
Mrs. Cora Morris,
Mrs. D. Hennen Morris,
Miss Eva V. C. Morris,
Henry Lewis Morris,
John Morris,
Lewis R. Morris,
Fred. V. Morrison,
Geo. Austin Morrison,
C. W. Morse,
Richard Mortimer,
Quincy L. Morton,
Henry C. Mott,
Mrs. H. W. Munroe,
Miss Catherine Murray,
J. G. Myers,
Nathaniel Myers,
Adam Neidlinger,
Edward M. Neill,
Wm. Nelson,
Miss Catherine A. Newbold,
Miss Edith Newbold,
Frederic R. Newbold,
H. Victor Newcomb,
Zenas E. Newell,
Geo. L. Nichols,
John B. Niles,
Wm. Nilsson,
John Notman,
Frederick J. Nott,
Mrs. Henry Noyes,
Anthony Oechs,
James H. Ogilvie,
E. E. Olcott,
Robert Olyphant,
Mrs. Emerson Opdycke,
Wm. S. Opdyke,
Mrs. Wm. Openhym,

William C. Orr,
Prof. Henry F. Osborn,
Augustus G. Paine,
N. F. Palmer,
S. S. Palmer,
Henry Parish, Jr.,
John H. Parker,
Henry V. A. Parsell,
Mrs. Phebe A. Parshall,
Charles Parsons,
Mrs. Edwin Parsons,
John E. Parsons,
W. H. Parsons,
W. A. Paton,
O. H. Payne,
T. W. Pearsall,
Mrs. Frederick Pearson,
Mrs. Alfred Pell,
Miss Frances Pell,
Stephen H. P. Pell,
Geo. H. Penniman,
Samuel T. Peters,
W. R. Peters,
Chas. Pfizer, Jr.,
Guy Phillips,
Lloyd Phoenix,
Phillips Phoenix,
Gottfried Piel,
Winslow S. Pierce,
Gifford Pinchot,
James W. Pinchot,
Mrs. James W. Pinchot,
Fred S. Pinkus,
Hon. Thos. C. Platt,
Gilbert M. Plympton,
H. F. Poggenburg,
Henry W. Poor,
A. S. Post,
H. A. V. Post,
C. A. Postley,
Miss Blanche Potter,
Frederick Potter,
Miss Martha Potter,
De Veaux Powel,
Anderson Price,
Chas. Pryer,
R. M. S. Putnam,
Percy R. Pyne,
Charles Raht,
Gustav Ramsperger,
Geo. Curtis Rand,
Edmund D. Randolph,
G. B. Raymond,
Geo. R. Read,
Wm. A. Read,
G. H. Redmond,
Whitelaw Reid,
Geo. N. Reinhardt,
E. B. Reynolds,
John B. Reynolds,
Miss Serena Rhinelander,
John Harsen Rhoades,
Auguste Richard,
Prof. P. de P. Ricketts,
John L. Riker,
Samuel Riker,
Wm. J. Riker,
R. Hudson Riley,
H. Dillon Ripley,
Dr. Wm. C. Rives,
Miss Mary M. Roberts,
Andrew J. Robinson,
Gen. Chas. F. Roe,
Edward L. Rogers,
Noah C. Rogers,
Theo. Rogers,
W. Emlen Roosevelt,
Mrs. W. Emlen Roosevelt,
Hon. Elihu Root,
Albert G. Ropes,

E. V. W. Rossiter,
Jacob Rothschild,
Wm. Rothschild,
Charles Runyon,
Jacob Ruppert,
Mrs. A. D. Russell,
Chas. Howland Russell,
Arthur Ryle,
Augustus St. Gaudens,
Clarence Sackett,
Mrs. Edward C. Sampson,
Daniel C. Sands,
Miss Marie L. Sanial,
Carl Schefer,
Miss Mary E. Schell,
J. Egmont Schermerhorn,
Mrs. H. M. Schieffelin,
Dr. Wm. Jay Schieffelin,
Gustave Schirmer,
Rudolph E. Schirmer,
Henry W. Schloss,
Miss Jane E. Schmelzel,
Henry W. Schmidt,
Paul G. Schoeder,
C. Schumacher,
Philip Schuyler,
C. M. Schwab,
Mrs. Gustav Schwab,
L. Henry Schwab,
Adolph Schwarzmann,
Geo. S. Scott,
John H. Screven,
Edward M. Scudder,
Geo. J. Seabury,
Francis K. Seagrist,
Mrs. Horace See,
Prof. Edwin R. A. Seligman,
George W. Seligman,
Jefferson Seligman,
T. G. Sellew,
Alfred Seton, Jr.,
Mrs. Clarence Seward,
W. H. Sheehy,
Edward M. Shepard,
Gardiner Sherman,
D. E. Sickles,
John W. Simpson,
W. T. Simpson,
John Sinclair,
Francis L. Slade,
Albert K. Smiley,
Daniel Smiley,
Chas. F. Smillie,
James D. Smillie,
Mrs. Annie M. Smith,
Chas. R. Smith,
F. M. Smith,
Mrs. George W. Smith,
James H. Smith,
James R. Smith,
Walter M. Smith,
Wm. A. Smith,
E. G. Soltmann,
Chas. Sooysmith,
Frederick Southack,
Samuel Spencer,
I. M. Spiegelberg,
Paul N. Spofford,
Miss Anna Riker Spring,
Dr. Edward H. Squibb,
John Stanton,
J. R. Stanton,
Louis M. Starr,
Jno. N. Stearns,
James H. Stebbins,
James R. Steers,
Charles H. Steinway,
Wm. R. Steinway,
Olin J. Stephens,
Benjamin Stern,

Isaac Stern,
Louis Stern,
Winfield S. Stern,
Alexander H. Stevens,
Frederic W. Stevens,
Dr. Geo. T. Stevens,
Lispenard Stewart,
Wm. R. Stewart,
Jos. Stickney,
Miss Clara F. Stillman,
Dr. D. M. Stimson,
James Stokes,
Mason A. Stone,
Sumner R. Stone,
William Stratford,
Chas. Strauss,
F. K. Sturgis,
Mrs. F. K. Sturgis,
Edmund Sturzenegger,
Rutherfurd Stuyvesant,
Mrs. Geo. Such,
Mrs. James Sullivan,
Lionel Sutro,
Mrs. P. C. Swords,
Miss Mary Taber,
Edward N. Tailer,
James Talcott,
C. A, Tatum,
Miss Alexandrina Taylor,
George Taylor,
Henry R. Taylor,
Stevenson Taylor,
C. H. Tenney,
H. L. Terrell,
John T. Terry,
Nikola Tesla,
Thomas Thacher,
Ernst Thalmann,
Dr. Allen M. Thomas,
Anthony J. Thomas,
Geo. C. Thomas,
Seth E. Thomas,
David W. Thompson,
John C. Thompson,
L. S. Thompson,
Mrs. Samuel C. Thompson,
Walter Thompson,
Dr. W. Gilman Thompson,
Samuel Thorne, Jr.,
W. V. S. Thorne,
H. L. Thornell,
C. C. Tiffany,
Louis C. Tiffany,
James Timpson,
J. Kennedy Tod,
William Toel,
Wm. Toothe,
William Tousey,
R. H. L. Townsend,
R. W. Townsend,
C. D. Tows,
J. Evarts Tracy,
Edwin D. Trowbridge,
Frederick K. Trowbridge,
Dr. Alfred Tuckerman,
Paul Tuckerman,
Geo. E. Turnure,
Benjamin Tuska,
Edward P. Tysen,
Edward Uhl,
E. S. Ullman,
Herbert Valentine,
Mrs. Lawsen Valentine,
Chas. H. Van Brunt,
Augustus Van Cortlandt,
Alfred G. Vanderbilt,
D. B. Van Emburgh,
E. H. Van Ingen,
W. Van Norden,
Edgar B. Van Winkle,

Miss Elizabeth Van Winkle,
Richard C. Veit,
Herman Vogel,
John Wagner,
Lewis Wallace,
Antony Wallach,
Wm. I. Walter,
Wm. T. Wardwell,
John H. Warren,
Allan C. Washington,
E. H. Weatherbee,
Mrs. H. Walter Webb,
Mrs. John A. Weekes,
Chas. Wehrhane,
Camille Weidenfeld,
Benjamin S. Welles,
Charles W. Wells,
Mrs. John Wells,
R. E. Westcott,
Geo. Westinghouse,
Dr. John McE. Wetmore,
Dr. Geo. G. Wheelock,
Dr. Wm. E. Wheelock,
Miss Caroline White,
Horace White,
N. H. White,
Stanford White,
Dr. Whitman V. White,
Wm. Henry White,
J. Henry Whitehouse,
Worthington Whitehouse,
James Whiteley,
Giles Whiting,
Clarence Whitman,
Wm. Wicke,
Edward A. Wickes,
D. O. Wickham,
M. T. Wilbur,
Robt. F. Wilkinson,
David Willcox,
Jno. T. Willets,
Robt. R. Willets,
G. G. Williams,
Richard H. Williams,
Mrs. Douw D. Williamson,
W. P. Willis,
Charles T. Wills,
Washington Wilson,
Wm. G. Wilson,
Egerton Winthrop,
Grenville L. Winthrop,
Mrs. Frank S. Witherbee,
Ernst G. W. Woerz,
Emil Wolff,
Lewis S. Wolff,
Mrs. Cynthia A. Wood,
James Wood,
John A. Woods,
F. F. Woodward,
Prof. R. S. Woodward,
W. H. Woolverton,
Miss Julia Wray,
Mrs. J. Hood Wright,
Arthur G. Yates,
C. S. Young,
Edw. L. Young,
Andrew C. Zabriskie,
Wm. Ziegler,
August Zinsser,
O. F. Zollikoffer.

REPORT OF THE TREASURER.

NEW YORK, January 12, 1904.

TO THE BOARD OF MANAGERS OF
THE NEW YORK BOTANICAL GARDEN.

Gentlemen: Herewith I submit a statement of my receipts and disbursements during the year 1903, and a balance sheet from my ledger as of December 31, 1903.

Respectfully yours,

C. F. COX,
Treasurer.

Receipts.

Balance as per last Annual Report.......		$ 15,742.08
Contributions of the City towards Development and Maintenance.............		103,504.71
Income from Investments:		
5 per cent. on $50,000 Southern Ry. Co. First Consol. Mtge. Bonds...$	2,500.00	
4½ per cent. on $50,000 Ches. & Ohio R. R. Co. Genl. Mtge. Bonds..................................	2,250.00	
4 per cent. on $50,000 Erie R. R. Co. Prior Lien Bonds..............	2,000.00	
4 per cent. on $59,000 Erie R. R. Co. Penn. Collat. Trust Bonds...	2,360.00	
4 per cent. on $50,000 Reading R. R. Co. Jersey Central Collat. Trust Bonds........................	2,000.00	
4 per cent. on $24,000 Nor. Pac. R. R. Co. St. Paul & Duluth Divn. Bonds.........................	960.00	
4 per cent. on $14,000 Nor. Pac., Gt. Northern, C. B. & Q. Collat. Trust Bonds.........................	560.00	12,630.00
Annual Dues.................................		9,140.00
Interest at 3 per cent. on balances on deposit with J. P. Morgan & Co..........		497.59
Proceeds Sales of Merchandise...........		22.25
do do of Publications...		187.06

Life Membership Fees..................			1,800.00
Tuition Fees, credited to Students' Research Fund................................			517.50
On a/c Bequest of Charles P. Daly, credited "David Lydig Fund".........			3,663.11
Contributions to Special Book Fund.....			3,312.88
do to Exploration Fund.......			1,555.00
do to Mus. & Herb. Fund...			1,405.00
do to Conservatory Fund......			300.00
			$154,277.18

Disbursements.

Expenses paid through Director-in-Chief a/c City Appropriation,	$103,504.71		
On General Account, for Vouchers paid..............	15,138.98	118,643.69	
Lectures and Literature on Preservation of Native Flora, account Income of Stokes Fund................................		86.83	
Books — account Special Book Fund....		4,891.69	
Plants — account Conservatory Fund	$667.89		
Less Sales........................	178.00	489.89	
Specimens, etc. — account Exploration Fund		1,455.86	
Specimens — a/c Museums and Herbarium Fund	$1,172.63		
Less Sales....................	29.50	1,143.13	
Publications — account Income of David Lydig Fund..................................		2,484.66	129,195.75
Balance — Cash in hands of Treasurer.			$ 25,081.43

LEDGER BALANCES, DECEMBER 31, 1903.

Credit.

Permanent Funds:

Endowment Fund.......................	$270,775.00
Fellowship Fees	8,000.00
Life Membership Fees................	16,500.00
Students' Research Fund..............	2,083.25

David Lydig Fund, Bequest of Chas. P. Daly		32,567.20
Stokes Fund		3,000.00
Temporary Funds:		
Special Book Fund, for Library		629.50
Conservatory Fund, for Plants		32.84
Exploration Fund		1,909.72
Museum and Herbarium Fund, for Specimens		726.25
Income Students' Research Fund		183.64
Income Stokes Fund		71.35
Income David Lydig Fund		279.46
Debit.		
Investments:		
Net Cost of $50,000 Ches. & Ohio Ry. Co. Genl. Mortgage Bonds $50,000 Southern Ry. Co. 1st Consol. Mtge. Bonds $50,000 Erie R. R. Co. Prior Lien Bonds $59,000 Erie R. R.-Penn. Collat. Trust Bonds $50,000 Reading R. R. Co.-Jersey Cent. Collateral Trust Bonds $24,000 Nor. Pacific R. R. Co. St. Paul & Duluth Div. Bonds $14,000 Nor. Pacific-Gt. Northern C. B. & Q. Coll. Tr. Bonds	$287,660.01	
Director-in-Chief, Working Fund	20,000.00	
General Income Account, balance borrowed from Permanent Funds	4,016.77	
Cash in hands of Treasurer	25,081.43	
	$336.758.21	$336,758.21

FEBRUARY 3, 1904.

DR. N. L. BRITTON, *Director-in-Chief*,
New York Botanical Garden,
Bronx Park, New York City.

Dear Sir: I beg to notify you that I have caused the accounts of the Treasurer of the New York Botanical Garden, Mr. Cox, to be examined and audited for the year 1903, and take pleasure in reporting that the same have been found to be correct, in accordance with the Balance Sheet and Statement of Receipts and Disbursements, enclosed herewith.

I enclose, also, the Auditor's Certificate.

Yours very truly,
(signed) JAMES A. SCRYMSER,
Chairman, Finance Committee,
New York Botanical Garden.

Members of the Corporation.

Prof. N. L. Britton,
Hon. Addison Brown,
Wm. L. Brown,
Andrew Carnegie,
Prof. Chas. F. Chandler,
Wm. G. Choate,
Hon. Edward Cooper,
Chas. F. Cox,
John J. Crooke,
W. Bayard Cutting,
Robert W. de Forest,
Cleveland H. Dodge,
Samuel W. Fairchild,
Gen. Louis Fitzgerald,
Richard W. Gilder,
Hon. Thomas F. Gilroy,
Parke Godwin,
Hon. Hugh J. Grant,
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Prof. James F. Kemp,
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Prof. Frederic S. Lee,
Hon. Seth Low,
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Edgar L. Marston,
D. O. Mills,
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Theo. W. Myers,
Geo. M. Olcott,
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George W. Perkins,
James R. Pitcher,
Rt. Rev. Henry C. Potter
Percy R. Pyne,
John D. Rockefeller,
Wm. Rockefeller,
Hon. Henry A. Rogers,
Prof. H. H. Rusby,
James A. Scrymser,
Henry A. Siebrecht,
Samuel Sloan,
Wm. D. Sloane,
Nelson Smith,
Dr. W. Gilman Thompson,
Louis C. Tiffany,
Samuel Thorne,
Prof. L. M. Underwood,
Geo. W. Vanderbilt,
William H. S. Wood.

VOL. 3 NO. 11

BULLETIN

OF

THE NEW YORK BOTANICAL GARDEN

[ISSUED APRIL 14, 1905]

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BULLETIN

OF

The New York Botanical Garden

Vol. 3. No. 11.

BOTANICAL CONTRIBUTIONS.

Mycological Studies. II.

BY F. S. EARLE.

1. New Species of West-American Fungi.

The following species were mostly collected by C. F. Baker in California and Nevada during 1901 and 1902. Many of them have been issued in his distributions of West-American plants. I am under obligations to him for full field-notes on the fleshy species, thus making it possible to study and describe them.

The types are deposited in the herbarium of the New York Botanical Garden.

HELOTIACEAE.

Lachnum atro-purpureum Durand, sp. nov.

Solitary or gregarious, stipitate, single or occasionally several (2–5) cups fascicled at the summit of each stem; disk concave, pale purple, externally dark purplish brown, paler toward the margin, clothed densely with hairs which are pale purple by transmitted light, cylindrical, smooth, closely septate, rather thick-walled, paler toward the tips, reaching 80 μ long, 5 μ thick; stem slender, as long as the diameter of the cup, hairy; asci clavate-cylindrical, 40–50 × 5–6 μ, not blue with iodine, apex rounded, scarcely narrowed; spores uniseriate, 8, hyaline, smooth, continuous, elliptical to elliptic-oblong, 6–8 × 2½–3 μ; paraphyses scarcely longer than the asci, narrowly lanceolate above, acute, 3–4 μ thick.

On dead *Eucalyptus* bark, Stanford University, Calif., Jan. 9, 1903. Collected by Copeland. Communicated by C. F. Baker as no. 2724.

A beautiful species peculiar in the often clustered cups, the purplish tint of every part, and the small spores. *Dasyscypha Eucalypti* (Berk.) Sacc., a purple species on *Eucalyptus* leaves in Tasmania, has larger (10–11 μ) spores and hairs in the form of teeth, belonging therefore in *Cyathicula*. The fascicled cups suggest the genus *Cordierites* and the color suggests *C. Sprucei* Berk., but the structure is in all other respects that of *Lachnum*. When dry the plant is purplish-black.

Mollisiaceae.

Mollisia papillata sp. nov.

Ascomata scattered, black, cup-shaped, rough-papillate, ½–1 mm., sessile, margin conspicuously elevated and inrolled when dry, disc dark slate-color to nearly black, peridial cells polygonal, becoming elongated toward the margin where they end in crowded clavate papillae about $25 \times 5\,\mu$; asci crowded, cylindrical, about $50 \times 4\,\mu$; paraphyses thread-like; ascospores obliquely monostichous or subdistichous, hyaline, continuous, cylindrical, often somewhat curved, $8–10 \times 2\,\mu$.

On old, weathered chips, foot-hills near Stanford University, California, Jan. 1, 1902, C. F. Baker, no. 207.

This is somewhat closely related to forms that have been referred to *Mollisia melaleuca* (Fr.) Sacc., but it is cupulate, not patellate, the disc is nearly black and the exterior is much more conspicuously roughened.

Tryblidiaceae.

Tryblidium Garryae sp. nov.

Ascocarps scattered, nearly or quite superficial, black, rough, patellate, margin obscure, about 1 mm. broad by 0.25 mm. thick; asci clavate, long-stipitate, about $120 \times 8\,\mu$; paraphyses thread-like, branched above; ascospores subdistichous, at first 1–4-septate and hyaline, at length dark brown, 10 or more septate and muriform, with numerous vertical divisions, usually somewhat curved, about $35 \times 14\,\mu$.

On decorticated, weathered twigs of *Garrya*, foot-hills near Stanford University, California, Jan. 1, 1902, C. F. Baker, no. 116*a*.

This species belongs to Saccardo's section *Tryblidaria*. In the Sylloge the name *Blitrydium* is used for this genus.

DOTHIDEACEAE.

Plowrightia Neo-Mexicana sp. nov.

Stromata at first buried, soon erumpent-superficial, black, rugulose, thin, crust-like, orbicular or often oval, about ½ mm. in diameter, usually aggregated and confluent in more or less elongated masses which reach 3 mm. or more in diameter; loculi several, 6 to 12 or more in each stroma, small, crowded, whitish within, slightly elevating the surface, ostiolum obscure; asci elliptic-oblong, short-pedicelled, aparaphysate, about $60 \times 14\,\mu$; ascospores distichous, hyaline, ovate, unequally uniseptate, strongly constricted, $20–22 \times 7–10\,\mu$, the smaller cell usually about $9 \times 7\,\mu$.

On dead, weathered stems of *Ampelopsis quinquefolia* (?), "The Gap," between San Ignacio and Las Vegas, New Mexico, July, 1902, T. D. A. Cockerell.

SPHAERIACEAE.

Melanomma Sambuci sp. nov.

Perithecia gregarious, often crowded, at first buried, soon erumpent-superficial, black, globose, rough, not collapsing, about $300–350\,\mu$, ostiolum obscurely papillate; asci clavate-cylindric, $90–110 \times 9–10\,\mu$; paraphyses abundant, thread-like; ascospores monostichous, fuscous, narrowly elliptical or narrowly ovate, 3-septate, slightly constricted, one medial cell often slightly enlarged, $20–25 \times 7–8\,\mu$.

On dead stems of *Sambucus*, Snow Valley Peak, Ormsby Co., Nevada, June 24, 1902, C. F. Baker, no. 1182 (in part).

CUCURBITARIACEAE.

Gibberidea Artemisiae sp. nov.

Perithecia clustered, two or three to six or eight on a scanty brownish stroma, or sometimes scattered, subglobose, at length slightly depressed, dark fuscous, nearly black,

subshining, about 500 μ, ostiolum minutely papillate; asci cylindrical, 100–120 $\times$ 8–10 μ; paraphyses thread-like; ascospores subdistichous, cylindrical, tinted or pale fuliginous, 3-septate, constricted, curved, 20–25 $\times$ 7 μ.

On shredded bark of *Artemisia tridentata*, King's Cañon, near Carson, Nevada, July 3, 1902, C. F. Baker, no. 1233*a*.

AMPHISPHAERIACEAE.

Melomastia Shastensis sp. nov.

Perithecia scattered or gregarious, the base sunk in the wood-fibers and often somewhat compressed by them, black, collapsing, 0.3–0.5 mm., ostiole depressed-perforate; asci cylindrical, 70–80 $\times$ 10–12 μ; paraphyses thread-like; ascospores subdistichous, irregularly oblong or narrowly ovate, hyaline, 3–4-septate, not constricted, one medial cell often slightly enlarged, about 25 $\times$ 5–6 μ.

On decorticated whitened wood of *Abies Shastensis*, Mt. Shasta, Calif., 7,500 ft., July, 1903, Copeland. Communicated by C. F. Baker as no. 3584.

MYCOSPHAERELLACEAE.

Mycosphaerella Balsamorrhizae sp. nov.

Perithecia thickly scattered over large areas, buried, black, lenticular, not collapsing, 200–225 μ, of rather loose cellular tissue, cells large, 10–12 μ, ostiolum minutely perforate; asci narrowly elliptical, short-stipitate, 60–70 $\times$ 14 μ; paraphyses none; ascospores distichous, narrowly ovate, unequally uniseptate, somewhat constricted, 18–20 $\times$ 7–8 μ.

On dead stems of *Balsamorrhiza* sp., King's Cañon, near Carson, Nevada, July 3, 1902, C. F. Baker, no. 1230.

Mycosphaerella Vagnerae sp. nov.

Perithecia thickly scattered over large whitened areas, minute, black, prominent, not collapsing, 100–150 μ in diameter, ostiolum inconspicuous; asci elliptical or often irregularly spindle-shape, 60–70 $\times$ 20 μ; paraphyses none; ascospores inordinate, elliptical, ends obtuse, uniseptate, hyaline, 16–18 $\times$ 6–7 μ.

On dead stems of *Vagnera* sp., King's Cañon, near Carson, Nevada, July 3, 1902, C. F. Baker, no. 1225.

Phaeosphaerella scirpicola sp. nov.

Perithecia scattered over the weather-bleached leaf-surfaces, subsuperficial, minute, black, membranous, about 25 μ; asci elliptical, 40–50 × 18 μ; paraphyses none; ascospores fascicled, cylindrical, about equally uniseptate, not constricted, hyaline till full maturity, then brown, with four prominent vacuoles in each cell, 30–35 × 4 μ.

On dead leaves of *Scirpus* sp., foot-hills near Stanford University, California, Jan. 1, 1902, C. F. Baker, no. 212.

PLEOSPORACEAE.

Didymella Delphinii sp. nov.

Perithecia abundantly scattered over large whitened areas, buried, at length partially exposed, black, subspherical, prominent, not collapsing, 250–300 μ in diameter, ostiolum minutely papillate; asci clavate, short-stipitate, 80–90 × 12–14 μ; paraphyses scanty, thread-like, delicate, inconspicuous; ascospores distichous, hyaline, narrowly ovate, or subellipsoid, somewhat unequally uniseptate, constricted, the larger cell often subacute, the smaller one obtuse, 20–25 × 7–8 μ.

On dead stems of *Delphinium* sp., head of Fall Creek, Ormsby Co., Nevada, July 15, 1902, C. F. Baker, no. 1331.

Pocosphaeria Dendromeconis sp. nov.

Perithecia gregarious in lines, buried, at length exposed by the breaking away of the host tissues, clothed with short brown hairs when young, becoming subglabrate with age and exposure, black, hard, subcarbonaceous, not collapsing, 250–350 μ, ostiolum inconspicuous; asci cylindrical, 100–120 × 9–10 μ; paraphyses abundant, thread-like; ascospores monostichous, light fuscous or yellowish, 3-septate, constricted at each septum, one medial cell slightly enlarged, one end cell conical and acute, the other rounded, 18–20 × 7–8 μ.

On dead stems of *Dendromecon* sp., foot-hills near Stanford University, California, Jan. 1, 1902, LeRoy Abrams, communicated by C. F. Baker as no. 224.

Metasphaeria Yuccae sp. nov.

Perithecia scattered, black, prominent, long, covered by the epidermis, at length suberumpent, about 200 μ, ostiolum

inconspicuous, subpapillate; asci elliptical, about $75 \times 12\,\mu$; paraphyses abundant, thread-like; ascospores distichous, hyaline, narrowly ovate, ends acute, 4-septate, strongly constricted at the second septum, about $20 \times 6\,\mu$.

On dead leaves of *Yucca* sp., Stanford University, California, Nov. 26, 1901, C. F. Baker, no. 17.

Pyrenophora Tetraneuridis sp. nov.

Perithecia scattered, buried, then erumbent, dark brown, not collapsing, about $200\,\mu$, ostiolum short-papillate, surrounded by a few stiff, brown, bristles; asci subcylindrical, about $175 \times 35\,\mu$; paraphyses thread-like; ascospores distichous, brown, elliptical, obtuse, 7-septate, not constricted, each cell 1–3 times vertically divided, about $40 \times 18\,\mu$.

On dead leaves of *Tetraneuris* sp., King's Cañon, near Carson, Nevada, June 14, 1902, C. F. Baker, no. 1068.

Pleospora Silenes sp. nov.

Perithecia gregarious on small blackened areas, prominent, soon free by the rupture of the thin cuticle, black, collapsing, about $200\,\mu$ in diameter, ostiolum minutely papillate, inconspicuous; asci cylindrical or narrowly elliptical, short-stipitate, thick-walled, about $140 \times 30\,\mu$; paraphyses thread-like, rather scanty; ascospores distichous, ovate or elliptical, compressed, dark brown, 3-septate, one or both of the medial cells once vertically divided, slightly constricted at all the septa, ends obtuse, about $30–35 \times 18\,\mu$ by $14\,\mu$ thick.

On dead stems of *Silene* sp., Clear Creek Cañon, near Carson, Nevada, July 5, 1902, C. F. Baker, no. 1255.

On some of the stems there is also a *Diplodia* with spores $14 \times 9\,\mu$. This may represent the pycnidial stage of the fungus.

Valsaceae.

Thyridium Sambuci sp. nov.

Perithecia thickly covering large areas, buried in groups of 6–8 or scattered, black, carbonaceous, not collapsing, $300–400\,\mu$ in diameter, ostiolum erumpent, minutely papillate, free (not valsiform); asci cylindrical, stipitate, $150–200 \times 17–20\,\mu$; paraphyses abundant, thread-like; ascospores monostichous, fuscous, elliptical, often slightly curved, 5-septate, constricted at the middle septum, one or more of the medial cells vertically divided, $30–35 \times 10–14\,\mu$.

On dead stems of *Sambucus*, Snow Valley Peak, Ormsby Co., Nevada, June 14, 1902, C. F. Baker, no. 1165.

DIATRYPACEAE.

Diatrype Baccharidis sp. nov.

Stromata thickly scattered, somewhat prominent, bordered by the wood-fibers, at length naked, black, rough, stromatic material scanty, tawny yellowish-brown within, about 1 mm. in diameter, often subconfluent; perithecia 3 or 4 to 6 or 8 in a stroma, large, 300–500 μ, subangular, black within, ostioles roughening the surface, compressed or obscurely bisulcate (subhysterioid) necks short; asci clavate, about 70 × 7 μ; ascospores curved, cylindric, yellowish, 12–14 × 2–3 μ.

On dead, weathered stems of *Baccharis* sp., Stanford University, California, Dec. 1, 1901, C. F. Baker, no. 182.

SPHAEROPSIDACEAE.

Coniothyrium Sambuci sp. nov.

Pycnidia scattered or somewhat gregarious, buried, at length fully or partially erumpent, black, globose, not collapsing, 300–350 μ in diameter, of firm cellular tissue, the cells small, regular, about 7–10 μ, ostiolum papillate; sporules dark fuscous, subglobose, about 8 × 7 μ; sporophores none or inconspicuous.

On dead, decorticated stems of *Sambucus*, Snow Valley Peak, Ormsby Co., Nevada, June 24, 1902, C. F. Baker, no. 1182 (in part).

What seems to be the same thing was collected at Chambers Lake, Colo., on *Sambucus*, Aug. 1, 1896, by the same collector and was issued as no. 412 under the name of *Coniothyrium olivaceum* Bon.; but it is not that species.

Diplodia Leptodactyli sp. nov.

Pycnidia scattered, buried, then erumpent, black, subglobose, not collapsing, 200–225 μ, of soft membranous tissue, cells regular, 8–10 μ, ostiolum inconspicuous; sporules brown, elliptical, uniseptate, somewhat constricted, ends obtusely rounded, about 14 × 8 μ.

On dead stems of *Leptodactylon squarrosum*, Clear Creek Cañon, near Carson, Nevada, July 11, 1902, C. F. Baker, no. 1308.

Diplodia Veratri sp. nov.

Pycnidia scattered over large areas, buried, often at length exposed, black, subglobose, not collapsing, 300–400 μ, wall tissue thick, opaque, of cells 8–12 μ in diameter, ostiolum minutely papillate; sporules subcylindrical, at length fuscous, 1-septate, little or not constricted, about $14 \times 7\ \mu$; sporophores not seen.

On dead stems of *Veratrum*, King's Cañon, near Carson, Nevada, June 2, 1902, C. F. Baker, no. 963.

Rhabdospora Datiscae sp. nov.

Pycnidia thickly scattered over extensive whitened areas, under the epidermis or at length erumpent, brownish-black, membranous, subglobose but slightly flattened, about 100–120 μ in diameter, with a perforate ostiolum; sporules acicular, straight, $35–50 \times 15\ \mu$.

On stems of *Datisca glomerata*, Stanford University, California, Nov. 11, 1902, Copeland. Communicated by C. F. Baker, no. 2648.

Rhabdospora Heraclei sp. nov.

Pycnidia thickly scattered over large whitened areas, black or dark brown, buried with the ostiolum erumpent, or exposed by the shredding of the host tissues, subglobose, not collapsing, about 400 μ in diameter, of thick firm cellular tissue, the cells rather larger, 8–10 μ, ostiolum prominently papillate, rather thick; sporules acicular, straight, multiguttulate, $30–40 \times 2\ \mu$.

On dead stems of *Heracleum lanatum*, Snow Valley Peak, Ormsby Co., Nevada, June 24, 1902, C. F. Baker, no. 1167.

Leptostromaceae.

Leptostromella (?) Eriogoni sp. nov.

Pycnidia scattered or gregarious in small groups, elongated, hysterioid, black, buried, becoming prominent, opening by a slit, $1–1.5 \times .5$ mm.; sporophores short, inconspicuous, about $7 \times 2\ \mu$; sporules cylindrical, hyaline, 3-septate, constricted at the septa, the cells at length separating, $18–20 \times 3–4\ \mu$.

On dead stems of *Eriogonum* sp., Little Valley, Ormsby Co., Nevada, Aug. 14, 1902, C. F. Baker, no. 1468.

This departs from the usual characters of *Leptostromella* in the constricted spores that finally separate at the septa.

Melanconiaceae.

Cylindrosporium Californicum sp. nov.

Occupying indeterminate brownish areas often involving half or more of the leaf-surface; ascervuli epiphyllous, abundant, covered by flesh-colored waxy masses of exuded conidia, 0.5 mm. in diameter; conidia cylindrical, usually irregularly curved, 35–40 × 3–4 μ.

On living leaves of *Fraxinus Oregana*, Stanford University, California, Oct., 1902, Abrams. Communicated by C. F. Baker, no. 2771.

This same fungus has been distributed by McClatchie, no. 895, under the name of *Cylindrosporium minor* E. & K. It differs from that species in the much larger indefinite spots and in the conidia which are about the same length but twice the diameter.

Boletaceae.

Boletus flaviporus sp. nov.

Among decaying oak leaves; pileus 6–9 cm., rather thin, convex to expanded, shining chestnut-brown, smooth, viscid, but not glutinous; hymenium plane, usually deeply depressed around the stipe but decurrent for nearly 1 cm. in anastomosing lines, bright lemon-yellow when young becoming a deep dark yellow or flavid with age (retaining this color in the dried specimen), pores angular, small (1 mm.), walls thin; spores yellow, narrowly elliptical, about 15 × 6 μ: stipe exannulate, 6–9 cm. × 18 mm., subequal or slightly ventricose, yellowish and smooth or marked with glutinous granules above, tomentose and white stained with brick-red below, solid; flesh whitish to brownish, unchanging, mild.

Stanford University, California, November 11, 1901, C. F. Baker, no. 131.

This striking species evidently belongs to the section *Viscipelles* although differing from the usual sectional characters in the deeply depressed hymenium and the reticulation at the apex of the stipe. It is remarkable for retaining so well the intense yellow color of the pores in the dried specimens.

Boletus tomentipes sp. nov.

Among decaying oak leaves; pileus fleshy, 3 cm. thick, 9–13 cm. in diameter, convex to expanded, clear brown (umbrinous), dry, at first minutely velvety-tomentose, becoming glabrate; hymenium ventricose, deeply and broadly sinuate-depressed, but with a decurrent margin that marks the apex of the stipe, sordid yellow, becoming brick-red when bruised or in drying, pores small, rounded (less than 1 mm. in the dried specimens); spores brownish, elliptical, about $14 \times 7 \mu$; stipe exannulate, 8–13 × 2.5–3.5 cm., cylindrical, densely but minutely velvety-pubescent, at length sometimes subglabrate above, brick-red, flecked with brown below, solid; flesh whitish or brownish-white, changing to blue when injured.

Stanford University, California, November 30, 1901, C. F. Baker, no. 132.

This species should be referred to the section *Subtomentosi* although in some of its characters it approaches the *Edules*. It is well marked by the double change of color when injured, the pores becoming brick-red while the flesh changes to blue. The specimens discolor badly in drying.

AGARICACEAE.

Collybia fimicola sp. nov.

On decaying horse manure in pastures; pileus thin, 2–5 cm., convex to expanded or somewhat depressed, subumbonate, sordid cinereous-brown, the center darker, smooth, shining, not striate; lamellae thin, rounded behind, slightly adnexed, interveined, heterophyllous, distant, ventricose, pale cinereous-brown; spores white, elliptical, $6 \times 4 \mu$; stipe 3–5 cm. × 3–5 mm., equal or slightly enlarged above, subglabrous above, densely hirsute-tomentose below, base brownish, apex nearly white (discolored in the dried specimens), cartilaginous, hollow; flesh thin, white, unchanging, mild.

Stanford University, California, November 30, 1901, C. F. Baker, no. 153.

Entoloma plumbeum sp. nov.

In old pastures, subgregarious; pileus 4–7 cm., irregular, often asymmetrical, expanded or at length depressed, pale

lead-color, often with a brownish tinge, center usually darker, smooth, not hygrophanous, margin irregular, not striate; lamellae narrowly sinuate, crowded, strongly heterophyllous, rather narrow, plane or subventricose, cream-color becoming tinted with salmon; spores pale salmon, elliptical, smooth, often with a large central vacuole, about $7 \times 5\,\mu$; stipe 2–3 cm. × 6–7 mm., equal, nearly smooth or subfibrillate, subconcolorous, sordid, solid, fleshy-fibrous; flesh white or cream-colored, unchanging, taste and odor mild.

Foot-hills near Palo Alto, California, March 11, 1902, C. F. Baker, no. 378.

Locellina Californica sp. nov.

In old pastures, solitary; pileus thin, 5–9 cm., becoming broadly expanded, pale tan-color, the center somewhat darker, slightly viscid when young but dry and smooth with age, margin entire; lamellae free, becoming remote with age, subcrowded, broad, plane or subventricose, pale brownish-salmon, then light cinnamon; spores rusty brown, irregularly elliptical, often with a minute oblique apiculus, large, $17–18 \times 8–9\,\mu$; stipe 6–12 cm. × 5–10 mm., subequal, apex discoid, base slightly thickened, minutely tomentulose, especially above, cream-color becoming light brownish on drying, solid, fleshy-fibrous; volva persisting as a thin, fragile, usually three-lobed, basal cup about 1 cm. high; flesh thin, white, unchanging, taste and odor mild.

Foot-hills near Palo Alto, California, March 11, 1902, C. F. Baker, no. 382.

This seems to be the first authentic species of this genus to be reported from North America. *Locellina Starnesii* Peck, Bull Torrey Club, **29**: 72, 1902, has a veil and annulus and should therefore be excluded.

Cortinarius speciosus sp. nov.

Among rotting oak leaves; pileus about 8 cm., convex to expanded, obtuse, pale yellow, disc darker, verging toward cinnamon, smooth, viscid, margin even; lamellae sinuate-decurrent, crowded, strongly heterophyllous, subventricose, at first sordid white then purplish, at maturity cinnamon; spores cinnamon, irregularly elliptical, ends subacute, $8–9 \times 6\,\mu$; cortina of reddish-brown fibrils attached to the margin of the bulb; stipe 5–6 cm. × 1–1.5 cm., strongly and abruptly

bulbous, the bulb 2.5–3.5 cm. thick, smooth above, fibrillose below from the fragments of the cortina, apex cream-color, base reddish-brown, solid; flesh whitish, unchanging, taste and odor mild.

Stanford University, California, December 4, 1901, C. F. Baker, no. 141.

This handsome, well-marked species belongs to the subgenus *Phlegmacium*, section *Scauri*.

Inocybe brunnescens sp. nov.

Pileus 3–7 cm., at first campanulate and subgibbous then obtusely expanded, bright shining-brown verging toward chestnut on the margin, the center paler, surface radiately fibrous, subglabrous but with a few minute floccose scales on the disc, margin even, occasionally splitting, at length revolute; lamellae subsinuate with a slightly decurrent tooth, subcrowded, broad, ventricose, edge erose, dark ochraceous-brown, edge often whitish; spores smooth, elliptical, about $10 \times 5\,\mu$; stipe 5–7 cm. × 8–12 mm., equal, smooth or with a few loose fibers, white, tinged with brown below, solid; flesh white, unchanging, taste and odor mild.

Among decaying oak leaves, Stanford University, California, November 30, 1901, C. F. Baker, no. 144.

This species belongs to the Section *Rimosae*. In color it closely resembles the dried oak leaves among which it grows.

Tubaria Eucalypti sp. nov.

On decaying fruits of *Eucalyptus*; pileus fleshy, 16–24 mm., broadly convex to expanded, ochraceous-brown, becoming paler on the disc with age, dry, minutely tomentulose especially on the margin when young, becoming glabrate, margin even, somewhat irregular; lamellae slightly decurrent, somewhat crowded, rather broad, plane, dark cinnamon, edge white; spores ferruginous, elliptical, $6–7 \times 3–4\,\mu$; stipe 2–4 cm. × 2–5 mm., equal or somewhat enlarged above, silky, fibrillate below, base white mycelioid, pale brownish, cartilaginous, hollow; flesh thin, white, unchanging, taste and odor mild.

Stanford University, California, November 22, 1901, C. F. Baker, no. 157.

This interesting little species seems to be confined to the one peculiar habitat.

Psilocybe Californica sp. nov.

In lawns and grassy places; pileus thin-convex to expanded and somewhat depressed, 1½–2½ cm., dark watery-brown when moist, pallid when dry, smooth or the disc somewhat wrinkled, moist, hygrophanous, margin even, lamellae somewhat decurrent, rather distant, interveined, subventricose, pale brown to fuscous; spores fuscous, subpellucid, elliptical, 6–7 × 3–4 μ; stipe 3–5 cm. × 2–3 mm., equal or slightly enlarged above, smooth, dark brown, cartilaginous, hollow; flesh very thin and watery, whitish, unchanging, taste and odor mild.

Stanford University, California, November 30, 1901, C. F. Baker, no. 152.

This species resembles *Psilocybe foenisecii*, which grows in similar situations in the Eastern States and in Europe, but the pileus is not at first campanulate, the lamellae are subdecurrent and interveined and the spores are much smaller.

2. New Tropical Fungi Mostly from Porto Rico.

The following undescribed species of fungi are mostly from an interesting collection of leaf-parasites made in Porto Rico by Mr. A. A. Heller, during December, 1902, and January, 1903. A few species are included from other localities. The types are in the herbarium of the New York Botanical Garden.

Hysteriaceae.

Lembosia Coccolobae sp. nov.

On living leaves of *Coccoloba uvifera;* epiphyllous, spots brown, at first often stellate, then orbicular, 4–6 mm., or confluent and somewhat effused; mycelium sparse, fuscous, rather widely effused, hyphae continuous or sparingly septate, occasionaly forking and anastomosing, slender, 3–4 μ thick; hyphopodia sessile, ovoid, dark fuscous, small, about 7 × 5 μ; ascomata scattered, discrete, black, linear, straight or slightly curved, ends obtuse, 300–600 × 100 μ; subiculum scanty, of

short parallel threads resembling those of the mycelium, 15–40 μ long; asci elliptical, 35 × 20 μ; ascospores inordinate, curved, unequally uniseptate, hyaline, 16 × 7 μ.

Porto Rico, Heller, no. 6375.

The spores do not seem to be fully matured. At full maturity they will doubtless be brownish and somewhat larger than indicated above. A sterile *Asterina* also occurs on some of the leaves. There is a specimen in the Ellis Herbarium labeled *Lembosia tenella* Lév., U. S. North Pacific Ex. Exped. C. Wright, 1853–56, that is evidently this species. Neither host nor locality is given and there is only a fragment of a leaf, but this is quite certainly *Coccoloba*. *Lembosia tenella* was described by Léveillé (Ann. Sci. Nat. III. 3: 58. 1845) on leaves of Myrtaceae from Tahiti. His description calls for a black radiating mycelium, forming round black spots 2–4 mm. in diameter. This is evidently different from our plant, where the mycelium is scanty and of such fine threads as to be invisible without high magnification.

PERISPORIACEAE.

Antennularia (?) tenuis sp. nov.

Epiphyllous; mycelium widely effused, forming a thin olive-brown pellicle, mycelial hyphae much interwoven, delicate, thin-walled, subhyaline, about 4 μ in diameter, frequently septate, the cells 12–18 μ long, at intervals forming *Torula*-like chains of oval cells, 8–10 × 5–6 μ; perithecia abundant, scattered, seated on the mycelium, black, globose, collapsing, of uniform rounded cells 8–10 μ in diameter, astomous, about 200 μ; asci elliptical, thin-walled, about 80 × 25 μ; paraphyses abundant, delicate, thread-like, ascospores inordinate, elliptical, obtuse, hyaline, 4–8 septate, the cells vertically divided, about 30 × 12 μ.

On leaves of *Musa* sp. (banana), apparently following plant lice. Porto Rico, Heller, no. 6352. Also on *Inga vera*. Porto Rico, Heller, no. 6353.

The generic position of this interesting fungus is somewhat doubtful. Its spore-characters do not accord with those usually given for *Antennularia* (*Antennaria*), but its biological habit is the same and it seems unwise to multiply

genera in this group of "honey dew" inhabiting fungi until their characters are better understood. *Triposporium*-like conidia are found on the same leaves and are probably connected with this fungus. The species is well characterized by the thin delicate mycelium and by the abundance of ascus-bearing perithecia.

Dimerosporium appendiculatum sp. nov.

Parasitic on the mycelium of an *Asterina*; mycelium scanty, of pale agglutinated threads 3 μ in diameter; perithecia globose, 70–100 μ, of soft, cellular texture, cells 6–8 μ, armed with 12–20 curved, dark fuscous, opaque, obtuse, appendages or setae which are 30–40 × 4 μ; asci fascicled, broadly clavate or narrowly obovate, stipitate, 8-spored, 35–50 × 10–12 μ; ascospores inordinate, pale fuscous, cylindrical, about equally uniseptate, scarcely constricted, 14–16 × 4 μ.

Parasitic on *Asterina Sidae* sp. nov.,* on leaves of *Sida carpinifolia*, Porto Rico, Heller, no. 6333 (type) and Jamaica, Earle, no. 363.

Meliola Andirae sp. nov.

Mostly epiphyllous, forming a widely effused brownish coating; mycelium of long, straight, seldom branching threads 7 μ in diameter, the cells usually 30–35 μ long; capitate hyphopodia small, opposite, distant, one pair to each cell, narrowly obovoid or subcylindric, 12–14 × 8–10 μ, the basal cell very short, only 2–3 μ; mucronate hyphopodia mostly opposite, densely crowded on certain threads, bottle-shaped, the neck often excentric and curved, 16–18 μ long; setae usually sparingly scattered, often more abundant near the perithecia, 200–250 × 7 μ, base tuberculate, tapering to a subacute point, apex usually strongly curved, pellucid; perithecia small, 150–200 μ, smooth, at length collapsing, of small, 6–10 μ, subprominent cells, ostiole none; asci 2–4-spored, soon evanescent; ascospores 4-septate, fuliginous, slightly constricted, obtuse, subcompressed, 35–40 × 9–12 μ.

On leaves of *Andira inermis*, Porto Rico, Heller, no. 6448.

This species is remarkable for the very long, straight mycelial threads, the small, opposite, very short-stalked, capitate hyphopodia and for the densely crowded mucronate

* See page 310.

hyphopodia which occur only on certain mycelial threads. The setae are sometimes straight but the great majority of them are strongly curved near the summit.

MELIOLA BICORNIS Wint. ?

Heller, no. 6259, on some unknown plant of the Leguminosae, Porto Rico.

This seems to be the same as Ule's Brazilian specimens issued under this name as no. 3545 of Rabenhorst-Winter, Fungi Europaei. These specimens are included under this species by Gaillard, Le Genre Meliola 99, but as the type of the species is from the island of St. Thomas off the coast of Africa the determination seems somewhat doubtful. No African specimens of the species have been seen.

Meliola Chamaecristae sp. nov.

Amphigenous and caulicolous, effused, forming a thin black coating; mycelial threads bright fuscous, uneven and wavy, 7–8 μ thick, cells 30–35 μ long; capitate hyphopodia alternate or scattered, irregular subcylindric, usually curved or circinate, 16–25 × 9–10 μ; mucronate hyphopodia not seen; setae infrequent, scattered, 200–250 × 7 μ, straight, tapering upward but obtuse, apex pale, pellucid; perithecia numerous, scattered, globose, small, 120–150 μ, thin-walled, subpellucid, slightly roughened by the convex uniform cells which are 10–12 μ in diameter; asci elliptical, mostly 4-spored; ascospores 4-septate, pale fuliginous, cylindrical, much constricted, obtuse, small, about 30 × 10–11 μ.

On leaves and stems of *Chamaecrista glandulosa*, Porto Rico, Heller, no. 6371.

This resembles *M. microspora* Pat. & Gaill. in the unusally small spores but differs in the larger capitate hyphopodia, the absence of mucronate hyphopodia, and the narrower and paler setae.

Meliola circinans sp. nov.

Forming irregular black velvety patches 5–10 mm. in diameter or widely confluent and effused, easily separating from the leaf; mycelium abundant, dark fuscous, branching anastomosing at wide angles, not agglutinated, somewhat

nodular and uneven, 6–7 μ thick, cells 16–20 μ long; capitate hyphopodia abundant, at first cylindrical, straight, even or irregularly lobed, 16–20 × 8 μ, then the apical cell becomes bent to one side and at length in some cases is completely coiled upon itself, in this condition being about 16 × 16 μ; mucronate hyphopodia infrequent, bottle-shaped, 16–20 × 6 μ; mycelial setae abundant, black, opaque, straight, simple, tapering to a point, 400–600 × 8–9 μ; perithecial setae 6–8 or more, scattered, dark fuscous, opaque, curved, rather obtuse, about 130 × 6 μ; perithecia globose, small, 120–150 μ, ostiolum not seen; asci soon evanescent, not seen; ascospores cylindrical, ends subapiculate, pale fuscous, translucent, 4-septate, constricted, 40–45 × 12 μ.

On leaves of *Rynchospora aurea*, Porto Rico, Heller, no. 6384.

I would include here Heller's no. 252 from Porto Rico, Sturgis' specimen from Grasmere, Fla., on *Cyperus* sp., Nash's no. 1803 from Eustis, Fla., on *Rynchospora dodecandra*, and Underwood's no. 1664, Fla., on "saw-grass." These have all been determined as *Meliola Cyperi* Patouillard, a species described from the Congo river, Africa. A portion of the type collection of this species is in the Ellis Herbarium. The American material certainly resembles it closely in having both mycelial and perithecial setae, a very unusual character, and in having more or less lobed and irregular capitate hyphopodia. It is clearly distinct however in the ultimate bending and coiling of the apical cell of the hyphopodia, which suggests the specific name. Both kinds of hyphopodia are much smaller than in *M. Cyperi*, the mycelial setae are shorter and thinner and the spores are subapiculate not obtuse. The most marked difference however is in the mycelium. In *M. Cyperi* the threads are 8–9 μ thick and are densely branched, the branches lying parallel and becoming partially agglutinated into a kind of crust. In *M. circinans* the threads average 2 μ smaller, and the branches are strongly divergent and not at all agglutinated.

Heller's no. 2249, from the Hawaiian Islands, distributed as *M. Cyperi*, is probably not that species, though it agrees with

it in the agglutinated crust-like mycelium. It certainly has no connection with the present species.

I would also include here Tracy's nos. 4079 and 7158 on *Cladium effusum*, Ocean Springs, Miss., and Braidentown, Fla. These have been distributed as *M. Amphitricha* Fr.

Meliola compacta sp. nov.

Amphigenous, forming compact, black, crusts 1–2 mm. in diameter; mycelial threads dark fuscous, 7 μ thick, densely crowded and agglutinated; mycelial setae none; capitate hyphopodia numerous, crowded, 18 μ long, the basal cell 8 μ long, the head cell globular, 10 μ in diameter; mucronate hyphopodia not seen; perithecial setae scattered, 70–100 × 6 μ, uniform in size, obtuse, often abruptly bent about 20 μ below the tip, the upper portion nearly hyaline; perithecia globose, 200–225 μ; asci elliptical, 4-spored; ascospores compressed, cylindrical, obtuse, 4-septate, constricted, dark fuscous, 40–45 × 14 × 10 μ.

On leaves of *Crossopetalum pallens*, Porto Rico, Heller, no. 6217.

This species is well characterized by the compact agglutinated mycelium, the peculiar perithecial setae and the compressed spores.

Meliola Compositarum sp. nov.

Epiphyllous; mycelium forming small, 1–2 mm., black or dark brown spots, scattered or sparingly confluent, threads 7 μ thick, cells 20–30 μ long; capitate hyphopodia alternate, 25–30 μ long, basal cell about 8 μ long, head cell irregularly lobed, 15–20 μ wide, occasionally elongate and uniseptate; mucronate hyphopodia usually opposite, bottle-shaped, crooked; setae none; perithecia globose, about 200 μ, with a group of 6–12 chitinized appendages near the apex, which are pale fuscous, 80–100 × 20 μ, the tip obtuse, abruptly uncinate and darker; asci usually two-spored, soon evanescent; ascospores cylindrical or narrowly elliptical, fuliginous, 4-septate, constricted, obtuse, about 45 × 14–16 μ.

Type, Heller's no. 6385 on *Willughbaea* sp., from Porto Rico. I place here also Heller's nos. 141 and 6185 on *Eupatorium* sp. from Porto Rico, my own no. 45 on *Eupatorium* sp. from Jamaica, and the specimens on some unknown com-

posite from Brazil collected by Ule and distributed as no. 3543 of Rabenhorst-Winter, Fungi Europaei, under the name of *Meliola inermis* Kalchbr. & Cooke. The latter was described on leaves of *Buddleya* from South Africa. Our species agrees with it in having peculiar chitinized uncinate perithecial appendages but in ours they are much larger, the spores are larger and the characters of the mycelium and hyphopodia are different.

Meliola Helleri sp. nov.

Amphigenous, mostly fruiting below, forming thin poorly defined black patches 3–6 mm. in diameter, often more or less confluent and effused, mycelium of somewhat interwoven, pale fuscous threads, 7 μ thick, cells 15–18 μ long; capitate hyphopodia alternate or unilateral, regular, oblong, 16–18 × 8 μ, basal cell short, about 5 μ, head cell cylindrical; mucronate hyphopodia infrequent, opposite, or scattered, subconic to subampulliform, often irregular, truncate, 18–20 μ; setae not abundant, 350–450 × 8 μ, opaque, straight, tapering upward, tip bifid for 4–6 μ or with two or more acute teeth; perithecia globose, 150–200 μ, smooth, of uniform subequal cells 8–10 μ in diameter; asci evanescent, not seen; ascospores 4-septate, dark fuscous, cylindrical, strongly constricted, obtuse, 35–40 × 11–13 μ.

On leaves of some unknown woody plant perhaps belonging to the Myrtaceae, Porto Rico, Heller, no. 6251.

This species seems to be nearly related to *M. bicornis* Wint., but differs in the characters of the hyphodia. From *M. bidentata* Cooke it can be distinguished by the more slender mycelial threads, smaller hyphopodia, smooth not verrucose perithecia and slightly smaller spores.

Meliola Mangiferae sp. nov.

Amphigenous, forming black, densely velvety, orbicular patches 6–10 μ in diameter or becoming widely confluent; mycelial threads numerous, much interwoven, dark fuscous, opaque, 10 μ thick, the cells 25–30 μ long; capitate hyphopodia irregularly clavate-oblong, alternate, 25 × 12–14 μ, basal cell 6–7 μ long, head cell irregularly cylindric, subflexuous; mucronate hyphopodia infrequent, subconical,

obtuse, often flexed and irregular, 25 μ long; setae very abundant, 600–700 × 11 μ, dark, opaque, tapering above to an obtuse tip that is usually divided into 2–5 short blunt teeth; perithecia globose, about 200 μ, somewhat roughened by irregular prominences composed of specially grouped cells (as in *M. Cookeana*); asci usually 2-spored, evanescent; ascospores 4-septate, constricted, broadly cylindrical, obtuse, dark fuscous, 50–55 × 18–22 μ.

On leaves of the Mango, *Mangifera Indica*, Castleton Gardens, Jamaica, Earle, no. 272. Also Porto Rico, Heller, no. 6393.

It forms conspicuous black velvety patches, and is well marked by the thick opaque mycelial threads, the abundant, long, densely opaque, slightly forked setae, the peculiar roughening of the surface of the perithecium and the large dark spores.

Meliola Psychotriae sp. nov.

Amphigenous but mostly epiphyllous, forming small black orbicular patches 1–3 μ in diameter; mycelium abundant, threads fuscous, 7–8 μ thick, cells 25–35 μ long; capitate hyphopodia alternate, usually closely appressed to the mycelial thread, about 25 × 10–11 μ, basal cell 7–8 μ long, head cell regularly elliptical; mucronate hyphopodia opposite, 16–20 μ long, subconical or the base slightly swollen, often curved, apex truncate; setae frequent, erect, 250–300 × 8 μ, tapering upward but obtuse, apex paler; perithecia small, 125–150 μ, subcollapsing, of small, compact irregular cells 7–8 μ in diameter; asci elliptical, 2-spored; ascospores 4-septate, elliptical, constricted, pale fuscous, ends narrowed but obtuse, about 35 × 13–14 μ.

On leaves of *Psychotria* sp., Porto Rico, Heller, no. 6252. Also on *Erithelis fruticosa*, Porto Rico, Heller, no. 6430.

This is perhaps nearest to *M. ambigua* Pat. & Gaill., but differs in the more slender mycelium and setae, the much smaller perithecia and the different characters of the hyphopodia and the broader more elliptical spores.

Meliola Thouiniae sp. nov.

Epiphyllous, forming thin blackish patches 3–6 mm. in diameter, often effused and indeterminate; mycelial threads

7 μ in diameter, frequently septate, the cells 12–16μ long; capitate hyphopodia numerous, alternate or occasionally opposite, regular, subcylindrical, 14–16 × 8–9 μ, basal cell very short, 3–4 μ, head cell elliptical, obtuse; mucronate hyphopodia numerous, opposite, usually nearly straight, narrowly conical to subampulliform, obtuse, about 20 × 7 μ; setae infrequent, 300–400 × 8 μ, straight, simple, opaque, abruptly tapering to an acute point; perithecia abundant, scattered, collapsing, ostiolate, small, 110–150 μ, smooth, of closely compacted cells about 8 μ in diameter; asci 2–3-spored, ovate, short stipitate, 40–50 × 25 μ; ascospores 4 septate, cylindrical, slightly constricted, obtuse, dark fuscous, 35–40 × 12–14 μ.

On leaves of *Thouinia stiata*, Porto Rico, Heller, no. 6435.

This species is nearest to *M. stenospora* Wint., but differs in the straight, not lobed or bent, capitate hyphopodia, in the larger, straight and more abundant mucronate hyphopodia and in the broader, more obtuse spores.

Pseudomeliola (?) collapsa sp. nov.

Parasitic on the mycelium of a *Meliola;* mycelium of slender agglutinated colorless hyphae, 2½–3 μ thick; perithecia densely aggregated, complete, at first lenticular, soon collapsing to saucer-shape, 100–120 μ, conspicuously ostiolate, of radiating agglutinated hyphae that are at length closely septate forming a tissue of rectangular cells 4–5 μ in diameter, ostiolum with the opening 8 μ in diameter with a slightly raised border which is provided with a circle of thread-like, closely appressed, radiating appendages which slightly exceed the margin of the perithecium; asci obovate, short-stipitate, 30–35 × 12 μ; paraphyses not seen; ascospores inordinate, cylindrical or subclavate, hyaline, conspicuously 3-guttate, 12–14 × 3 μ.

On the mycelium of *Meliola torulosa* Wint. on leaves of *Piper peltatum*, Porto Rico, Heller, no. 6400 (type), also Heller, no. 6401, on *Meliola* sp. on *Mesosphaerium capitatum.*

This peculiar species is referred to the above genus with much doubt. The radiating prosenchymatous tissue of the perithecium and its conspicuous ostiolum point to a relationship with the Microthyriaceae rather than to the Perisporiaceae

where *Pseudomeliola* has been placed. On the other hand, the perithecium is evidently complete, the upper and lower walls being both fully developed, in which it agrees with the Perisporiaceae. The spores are shorter than in the type of *Pseudomeliola* and it is possible that they ultimately become 2-septate.

MICROTHYRIACEAE.

Asterina Sidae sp. nov.

Mostly epiphyllous, forming poorly defined, thin, blackish patches 2–4 mm. in diameter; mycelium scanty, of zigzag radiating threads about 4 μ thick; hyphopodia sessile, irregular and conspicuously three- or four-lobed, 7–8 μ; perithecia numerous, scattered, 80–100 μ, convex-applanate, of dark, opaque, closely agglutinated, radiating hyphae, subostiolate, splitting stellately; asci subglobose, 8-spored, 20–25 μ; ascospores inordinate, ovate, somewhat unequally uniseptate, strongly constricted, fuliginous, 14 × 8 μ.

On living leaves of *Sida carpinifolia*, Jamaica, Earle, no. 366 (type); Porto Rico, Heller, no. 6333.

Parasitized by *Dimerosporium appendiculatum* sp. nov.* The parasite is much more abundant on the Porto Rican specimens.

Asterina triloba sp. nov.

Epiphyllous, forming black patches 2–4 mm. in diameter or often confluent; mycelium rather scanty, of dark fuscous threads, about 4 μ in diameter, hyphopodia scattered, sessile, irregular, but usually three-lobed, about 7–8 μ; perithecia abundant, shield-shape, consisting of radiating threads, some of which exceed the margin, forming an irregular *Lembosia*-like subiculum, 30–50 μ wide, rupturing stellately, 90–120 μ in diameter; asci broadly ovate to suborbicular, about 25–30 μ, ascospores hyaline to full maturity, then dark brown, about equally uniseptate, constricted, elliptical, ends obtuse, about 20–25 × 8–9 μ.

On living leaves of *Croton discolor*. Limestone hills, along the coast west of Ponce, Porto Rico, Heller, no. 6216.

This differs from *Asterina crotonicola* Pat. in the three-lobed hyphopodia and smaller spores. The specimens also show abundant dark brown, opaque, obovate conidia, about

* See page 303.

18 × 12 μ, borne at the ends of delicate hyaline hyphae, about 12 × 3 μ. What connection, if any, these have with the *Asterina* could not be determined.

Micropeltis longispora sp. nov.

Epiphyllous; perithecia scattered, easily separating, dark brown, slightly roughened, 300–400 μ, hemispheric-applanate, umbilicate, the ostiolum slightly sunken, of prosenchymatous tissue composed of fine interwoven threads, which extend beyond the fertile portion, forming a flat, sterile subiculum 100–200 μ wide; asci elliptical, aparaphysate, 70–80 × 25–30 μ; spores cylindrical, often curved, hyaline, multiseptate, granular, ends obtuse, 50–70 × 8 μ.

On living leaves of *Coffea Arabica*, Porto Rico, Heller, no. 6349.

The leaves are also overrun by the sterile mycelium of some *Apiosporium*.

This differs from *Micropeltis Tonduzii* Speg. in the larger, much more frequently septate spores which have the cells all equal, not one or two of them enlarged as in that species.

Diatrypaceae.

Diatrypella Lantanae sp. nov.

Stromata scattered, prominent, bordered by the epidermis, black without and within, stromatic material scanty, usually elliptical, about 1 × 0.75 mm.; perithecia four or five to ten or twelve in each stroma, black, globose, 400–500 μ, ostiolum short, smooth, umbilicate; asci broadly clavate, crowded with spores, short-stipitate, 70–80 × 10–12 μ; ascospores very numerous in each ascus, allantoid, yellow, about 7 × 1.5 μ.

On dead stems of *Lantana camara*, Hog Island, Florida, April 18, 1900, S. M. Tracy, no. 6773.

Xylariaceae.

Kretzschmaria rugosa sp. nov.

Stromata reaching 1 cm., irregularly globose or subdepressed, short-stipitate or subsessile, surface dull black, rough, substance spongy-fibrous, white, stipe 2–8 × 1–2 mm.;

perithecia large, 1 mm. in diameter, black, globose, buried but prominent, monostichous, scattered, not crowded, ostiolum minute, punctiform, inconspicuous; asci cylindrical, 150–200 × 8–10 μ, evanescent, disappearing before full maturity; paraphyses delicate, thread-like, 1 μ thick; ascospores monostichous, inequilateral, often curved, at first hyaline with one or two large vacuoles, becoming brown and opaque, 25–28 × 8–10 μ.

On a dead log in the forest, Molyneaux Estate, Island of St. Kitts, September, 1901, Britton & Cowell, no. 337.

DEMATIACEAE.

Cercospora conspicua sp. nov.

Amphigenous, densely covering areas 3–6 mm. in diameter, with a conspicuous olive-gray tomentum or by confluence involving large portions of the leaf; conidiospores densely aggregated, olivaceous, somewhat torulose and irregular, occasionally septate, 30–40 × 3–4 μ; conidia slender, clavate, subhyaline, continuous or at length faintly septate, 40–60 × 2–3 μ.

On living leaves of *Cleome pentaphylla*, Porto Rico, Heller, no. 6152.

The Comparative Embryology of the Cucurbitaceae.

By Joseph Edward Kirkwood.

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PART I. INTRODUCTION

This work was begun at Princeton in the year 1898 while the writer was special fellow in biology in Princeton University. *Sicyos angulata* L., which was found growing in that vicinity, seemed to be a favorable object for study and some of the inflorescences were accordingly gathered and a brief examination made of the development of the gynoecium and the embryo-sac.

Though the results of this study were somewhat meager, it was nevertheless thought advisable to continue the work and extend the investigation to other members of the Cucurbitaceae. This was undertaken at the suggestion of Professor F. E. Lloyd, and carried on during the years 1899 and 1900 and the summer of 1902 at the New York Botanical Garden.

The characters of certain members of this large and interesting family suggested an attractive problem in the comparative organogeny of the flowers. In this work special attention has been given to the organogeny of the gynoecium. Some evidence has been collected as to the nature of the inferior ovary in this family and a discussion of the literature on this point will be presented later (Part III).

Besides the morphology of the flower there are interesting facts in connection with the development of the embryo-sac and associated structures which deserve attention. But the

morphological problems involved in this study are of less importance, in the writer's estimation, than are those of a physiological character. The structure of the embryo, the growth and character of the endosperm, the distribution of nutritive materials in the ovule and the placenta, all are matters of importance; an understanding of the physiological conditions obtaining in the ovule is no small aid to the interpretation of various structures and phenomena, and this conception is becoming more and more the dominant idea in modern investigations. "An account of organic evolution, in its more special aspects, must be essentially an account of the interactions of structures and functions," are the words of Herbert Spencer, quoted and emphasized by Goebel in his *Organography*. The fruitfulness of this thought is brought more strikingly to our attention when we consider the trend of later researches and the character of their results.

Treub[82] in his memorable work, *Notes sur l' embryogénie de quelques Orchidées*, emphasized the thought that the manner in which the embryos absorb the plastic substances certainly deserves to attract attention, and further, that the problem should be elucidated by embryological researches. While, as has already been said, this view has dominated much of the embryological investigation of more recent years, the importance of the problem was recognized before the publication of the work just cited, as Treub himself points out. Hofmeister[41] (1849) saw and described antipodal cells and attributed to them the function of elaborating food for the young embryo, although in a later work[42] (1867) he says that the antipodals are meaningless in the development of the embryo and that after fertilization they develop no further but are themselves soon dissolved. Twenty-five years later, however, Westermaier[88] takes up the subject of the antipodals and in conclusion says: "In the development of the so-called antipodal cells in the embryo-sac of angiosperms, contrary to former views, one has to deal with an anatomical-physiological apparatus and not with a useless rudimentary structure which would be incomprehensible ex-

cept from the standpoint of comparative morphology." The grounds upon which a physiological meaning is given to the cases in question are particularly:

(1) In the specific position of these cells in the embryo-sac and in the quality of the contents of the cells themselves.

(2) In their anatomical relations and the character (cuticularized) of certain membranes in the ovule.

(3) The manner of starch distribution in the inner part of the nucellus.

In 1896 he refers[89] to the work on *Nigella* (1890) in which he ascribed to the polar nuclei or later the endosperm nucleus the function of conserving the antipodals in spite of the lengthening of the embryo-sac and of fixing the said apparatus in closer proximity to the micropyle in the interest of the first embryonic development. He concludes by saying: "The antipodals are a nourishing apparatus for the embryo in the foetal developmental period."

We find this view strengthened by the results of the work of Campbell[11] on *Sparganium* and Chamberlain[16] on *Aster*, in which cases the antipodals seem to have an important nutritive function. Merrell,[58] however, regards the antipodals of *Silphium* as performing the function of conduction of nutritive substances, and Mlle. Goldflus[31] interprets the antipodals in several genera of the Compositae as haustoria, from the fact that they elongate and appear to be associated with certain conducting tissue at the base of the ovule. Evidence on this point has also been found in *Callipeltis* and *Galium*.[53] To this view, moreover, we were directed by the form and structure of these cells in another family of plants (Liliaceae) investigated by Ikeda,[44] who finds similar anatomical features. The cells themselves show the phenomenon of chromatin aggregation, indicating metabolic activity, and these stand in relation to elongated cells of the nucellus which extend to the chalaza, forming a "conducting passage." At the same time certain features in the distribution of starch and soluble carbohydrates, dextrin, etc., indicate that the center of activity for the elaboration of food for the embryo is the antipodals.

At this point attention may be called in passing to the more recent investigations which have shown certain peculiarities in the part which the endosperm plays in the nutrition of the embryo. Balicka-Iwanowska[4] in studying the embryo-sac of a number of sympetalous genera found both micropylar and chalazal haustoria of endospermic origin. In a recent contribution, Johnson[47] has pointed out the digestive function of the endosperm in the perisperm-bearing seeds of certain Piperaceae.

Attention has repeatedly been called to the function of the suspensor as a means of conducting nutritive substances. In 1858 Hofmeister[48] stated that an unusually long and well developed suspensor is accompanied by weakly developed or almost entirely suppressed endosperm in *Tropaeolum*, *Trapa*, the Geraniaceae and the Caryophyllaceae. Treub[83] concluded that the suspensor performed a physiological function in the transmission of nutritive substances, and that the want of a suspensor was correlated with the character of the outer cell-walls of the embryo. He says in substance that the embryos are nourished by means of strongly developed suspensors; while the outer cell-walls of the embryos are strongly cuticularized, the suspensors of these on the contrary consist of pure cellulose (*Herminium Monorchis*). Embryos with rudimentary suspensors or none at all, had a thin and permeable cuticle. In the Leguminosae, Guignard[36] found cases in which embryos with rudimentary suspensors or none at all were at a very early stage completely surrounded by endosperm. The development of the complex coenocytic suspensor of *Orobus* is accompanied by the scanty formation of endosperm, and the author suggests that it may find its chief function in the nutrition of the embryo.

The work of Koorders[51] furnishes us with a unique case in which the suspensor acts as a means of transmission of nutritive materials which it obtains through certain of the endosperm cells that attach themselves to the suspensor and elongate into tubular bodies, acting as haustoria. In this case the embryo is cuticularized over its outer surface until the coty-

lendons are differentiated, whose peripheral cells possess thin and permeable walls.

In the Galieae Lloyd[53] reports cases analogous to that found by Koorders[51] in *Tectonia*. In *Vaillantia* and *Galium* some of the cells of the suspensor elongate laterally to form haustoria which penetrate the surrounding endosperm to a considerable depth, seemingly, as the author suggests, increasing the surface for absorption, and thus providing for a rapid growth of the young embryo.

In some of the later researches the behavior of the pollen-tube has been carefully considered. Longo[54] finds that in *Cucurbita Pepo* it follows a definite conducting tissue from the stigma to the embryo-sac. In the apical region of the nucellus the tube expands and sends branches into the surrounding tissues, the branching being correlated with the distribution of starch in those parts. It is the thought of Longo that the growth of the pollen-tube along the conducting tissue is an expression of chemotropism, in which he is in accord with the views of Molisch. In different species of the same genus Longo shows that the pollen-tube may pass through the conducting tissues or on their surfaces in ovarian spaces, the stimulus being in the nature of a secretion. Lloyd found in *Diodia* and *Richardsonia* that the pollen-tube was endotropic and ectotropic in different parts of the same ovary. He concludes that the behavior of the pollen-tube, whether ectotropic or endotropic, is a purely physiological character, and of no phylogenetic significance as interpreted by Treub and Nawaschin.*

The growth of the pollen-tube toward the ovule and its ultimate arrival at the embryo-sac indicate either some mechanical relations (Miyoshi)[62] or the differential distribution of the stimulant by which it may be directed chemotropically. That the source of this stimulant is either the oösphere or the synergids there is some reason to believe, and this view has already been advanced by Lloyd.[53]

*See Lloyd: The pollen-tube in the Cucurbitaceae and Rubiaceae. Torreya, 4: 86–91. June, 1904.

Whether we are to regard the synergids as a center for the distribution of a stimulant or as a means of transmission of the generative nuclei of the pollen-tube is difficult to determine. Indeed they may perform both of these functions. That the physiological properties of the different embryo-sac cells are variable there is abundant evidence. Dodel[20] describes the fertilization of synergids in *Iris Sibirica*. Embryos are occasionally derived from antipodals (Tretjakow[84]), and the fertilization of the polar nuclei is now known to occur in many plants.

Investigations relative to the embryo-sac and associated structures in the Sympetalae have been particularly abundant in recent years. We have the works of Chamberlain,[16] Merrell,[58] Goldflus[31] and Juel[48] on the Compositae; of Balicka-Iwanowska[4] on the Scrophulariaceae, Plantaginaceae, Campanulaceae and Dipsaceae; of Guignard[36] on the Solanaceae; of Lloyd[53] on the Rubiaceae; of Billings[7] on the Caprifoliaceae, Globulariaceae, Goodeniaceae, Hydrophyllaceae and Primulaceae; and numerous others. Very little, however, has been done upon the Cucurbitaceae.

The first work of any importance which touches the embryology of the Cucurbitaceae was that of Brongniart[8] in 1826. In this he has figured better than he has described the embryo-sac of *Pepo macrocarpus* and *Momordica Elaterium*. In the former the anatomy of the ovule corresponds to the general type and is essentially correct. While most of this work has to do with the process of fertilization and will be referred to later, it is interesting to note that in *Pepo* the peculiar form of the endosperm in its coecum-like prolongation towards the chalaza is figured with approximate accuracy, and the action of endosperm upon the nucellus is also shown in *Momordica*.

Mirbel[60] in 1829 describes the structure of the ovule and embryo-sac in *Cucumis Anguria* and *C. leucantha*. He points out the fact that the young ovules are at first mere protuberances, and clearly shows that the relations of the micropyle and chalaza are maintained during the turning of an anatropous ovule and that the development of the raphe

brings it about that the hilum is removed from the chalaza and its position near the micropyle is attained. The chalaza is recognized as a center for the distribution of nutritive substances to the nucellus and the integuments. In *C. leucantha* he figures the endosperm in an advanced stage as occupying about half of a cavity in the nucellus and in form an ovoid mass with a tube-like prolongation at its lower end. The embryo is represented at this stage in about its proper size and appearance as a narrowly pyriform mass and of about one sixth the length of the endosperm.

In 1842 Amici * studied the process of fertilization and development in *Cucurbita Pepo*, but his work was faulty, as Schleiden later points out. Amici failed to recognize an embryo-sac in the unfertilized ovule, or prior to the opening of the flower. He thought he saw and accordingly described a canal extending through the apex of the nucellus, through which the pollen-tube passed in the process of fertilization. In the growth and development of the endosperm essentially the same features are represented as were shown by Mirbel in the case of *Cucumis leucantha*, and in this respect he is correct. In his figures his representations of the form and structure of the ovule are in the main correct, but he failed to recognize the embryo and to interpret correctly the structures surrounding it. His observations, however, upon the rate of embryo-sac development after fertilization are worth noting as being the first record of such growth. He shows that the enlargement of the embryo-sac was apparent during the first day after fertilization. When the fruit is one and one half inches thick the coecum-like prolongation of the embryo-sac has elongated to about one fourth the length of the nucellus. In a fruit four inches in diameter, he shows, this tube has practically reached to the chalaza.

Schleiden[74] in 1844 expresses surprise that no one in the company of botanists to whose attention Amici's paper came was able to detect the errors which it contained, and declared that Amici had no knowledge of the ovule in general nor of

* See Facchini.[82]

the Cucurbitaceae in particular. He declares that Amici had taken the inner integument for the nucellus and the nucellus for the embryo-sac. Schleiden contends that the embryo-sac is present before the opening of the flower, that there is no canal in the apex of the nucellus, and states that he, himself, has traced the pollen-tube in its course in *Pepo*, *Melo*, *Cucumis*, *Lagenaria* and *Momordica*, and especially in *Momordica* has seen the male generative nuclei emerge from the pollen-tube.

In the following year Facchini[23] came to the defense of Amici, stating the nine propositions which that author published, along with his plates. The effort, however, to vindicate Amici was not very successful.

In the same year (1845) Schleiden[75] returned to the attack and gave us the first account of the embryo-sac before fertilization in any of the Cucurbitaceae. In *Cucurbita Pepo* he figures an ovule with its parts correctly differentiated and states that the small embryo-sac is present before the opening of the flower, and that it has only slightly enlarged at the time of the entrance of the pollen-tube. He says further: "It is easy to observe the pollen-tube in its course from the stigma through the conducting tissue. At the time when the flower wilts and falls off, the tubes have reached the ovules, in some cases at least. The ovary at this time is about 21 mm. long and 18 mm. in diameter. When the ovary has become 35 mm. long and 22 mm. in diameter the ovule is 4 mm. long, 2 mm. broad and 1 mm. thick. When the pollen-tube has reached the apex of the nucellus the latter has partly broken down: the pollen-tube quickly runs through its length, bulges out in it and fills it with a starchy substance so that it is quite dense. The pollen-tube and the embryo-sac seem to be fused together." The tip of the nucellus, he further states, becomes disorganized as the pollen-tube expands in it, and immediately afterwards the extension of the embryo-sac toward the chalaza begins. When the ovary has reached the length of fifty millimeters the oöspore becomes visibly cellular in structure.

Hofmeister[41] in 1849 describes certain features of *Cucurbita*, *Sicyos*, and *Ecballium*. He points out the fact that in these cases the embryo-sac before fertilization is very small compared with the size of the nucellus, that in each case it lies directly under the apex of the nucellus, which has a central row of cells with transparent contents. This condition probably led Amici to the view that the nucellus was traversed by a canal in its apical region. The main points which were contributed from Hofmeister's researches may be summed up as follows: Shortly before the opening of the flower two nuclei appear at each end of the embryo-sac. Germinal nuclei arise from the micropylar cells with some exceptions (probably polar nuclei). The antipodals form no walls about themselves and their life is usually short. The oösphere is at first conical but later becomes elongated. The pollen-tube finds the micropyle while the flower is still fresh, penetrates the apex of the nucellus, and while surrounded with this tissue shows (upon treatment with potash) a wall transversely striated. The pollen-tube lies against the embryo-sac and does not effect an entrance for about forty-eight hours, more or less. During this time the ovule retains its dimensions. Fertilization takes place suddenly, the embryo-sac increases from four to five times in length and twice in breadth. The oöspore divides once transversely and the distal cell becomes the proembryo. The proembryo divides longitudinally forming two cells (*Ecballium*). A layer of free nuclei lines the embryo-sac and these form walls about themselves; a second layer is then formed, followed by a third, etc., until the embryo-sac is filled. It thickly surrounds the conical embryo, which must in turn replace it in its progress of development to the ripe seed. When the embryo is a conical mass of cells the endosperm occupies about one sixth of the space of the nucellus. Later stages show important features. Endosperm rapidly replaces the tissue of perisperm, especially about midway between micropyle and chalaza. The young embryo, from which the suspensor has already disappeared, soon shows radicle and

cotyledons. The cotyledons grow very rapidly and replace the endosperm as rapidly as the latter did the perisperm. In *Ecballium* the rapidly developing endosperm performs the work of digestion. In *Cucurbita* he states that the endosperm fills the embryo-sac later than in *Ecballium*. In *Sicyos* the oösphere appears elongated, and there are numerous antipodal cells. Hofmeister thought that the ovules in all the Cucurbitaceae develop in about the same way as in *Ecballium*. His results are not entirely in accord with those of Schleiden, especially in the matter of the phenomena accompanying fertilization. But on the whole the work of Hofmeister is a distinct advance over anything that had so far been done. From the study of the material at the present time, however, it would be impossible to confirm in all points the account which he gave to science in the classic work just cited. Considering the conditions under which Hofmeister worked, we are the more surprised that the work was as accurately done as it was. There were many points difficult of demonstration which have been clearly set forth in his work, which we with all our knowledge of technique have not been able to change materially. Our knowledge of the processes of spore development, fecundation, and embryology in the Cucurbitaceae remain to-day substantially as Hofmeister left them over fifty years ago. His work on this family was not in all points correct, as will appear when we come to the discussion of some of the particular types of which he treats.

While attention has been given to the structure of the ovule and the phenomena of embryonic growth, practically nothing has been contributed in regard to the earlier stages of development, and what has been described of the later phases has been of a very brief character with reference to a few particular forms. In some forms the development of the microspores has received attention, but nothing has been done on the character of the nuclear divisions of the spore-mother-cells. Some observations have been made upon the development of the ovule and upon the placentation, and some upon the general organogeny of pistillate and staminate flowers, more

particularly the former. It still appears to be an open question as to the morphological nature of the androecium and little or nothing has been done to compare the earlier stages of development in widely differing representatives of this family. It shall be the aim of this paper to follow, as closely as the writer has been able to observe, the process of development of the essential organs in the pistillate flowers, to describe the anatomy of those organs especially with reference to the work of fecundation and seminal development, and the behavior of the pollen-tube. It is hoped that light may be thrown upon the morphology of the floral organs and upon the problems of nutrition.

The methods used were those most commonly employed in embryological researches. The material was fixed by two methods, viz., the use of Flemming's stronger solution, and of an acetic-acid-alcohol mixture in which the ingredients were in the following proportions: glacial acetic acid 1 part, 70 per cent. alcohol 2 parts. The latter proved to be more satisfactory in some cases, where the presence of oil in the embryo-sac and vicinity rendered the use of osmic acid mixture inconvenient. In the use of both media, however, good fixations generally resulted.

In this connection the writer desires to express his appreciation of the kindness of those who have in various ways assisted in this work: to Professor F. E. Lloyd, at whose instance this problem was undertaken and whose helpful suggestions have from time to time been very acceptable; to Professor N. L. Britton and Dr. D. T. MacDougal, through whose courtesy the author was given the privileges of the laboratories and plantations of the New York Botanical Garden during the summer of 1902; also to Hon. William Fawcett, Director of the Hope Gardens at Kingston, Jamaica, who so kindly furnished the material of *Fevillea*, to Dr. David Griffiths for the material of *Apodanthera*, and to Messrs. Peter Henderson & Co. for the use of plants on their trial grounds on Long Island.

PART II. DESCRIPTIVE

The Cucurbitaceae constitute a family of plants whose systematic position and relationship have been much disputed. Naudin and also Bentham and Hooker[6] have considered them more nearly allied to the Passifloraceae. Baillon[3] has regarded them as related to the Loasaceae and Begoniaceae. They are usually regarded, however, in accordance with Braun's view, as near relatives of the Campanulaceae, from which they are separated chiefly by the character of the androecium and the lack of latex vessels.

Eighty-five genera, of which by far the larger number belong to the Eastern Hemisphere, constitute this family. They are mostly natives of the tropical or subtropical latitudes, a few only being natives of the temperate zones. For this reason the obtaining of material for this study has been beset with difficulties. Material suitably prepared was difficult to obtain from the native habitats of some of the desirable forms, and those cultivated at New York City and Syracuse, N. Y. were in many cases unproductive. The eighty-five genera fall naturally into five tribes recognized by Engler and Prantl.[64] Of the eight tribes into which the family was divided by Cogniaux[20] four have been reduced very properly, it would seem, to subordinate rank. The tribes as they shall be considered here are the Fevilleae, Melothrieae, Cucurbiteae, Sicyoideae and Cyclanthereae.

The forms which have been studied in connection with this work comprise seventeen species selected partly because they were the best available, but at the same time an effort was made to obtain forms which would be as typical as possible of different tribes and representative of the most widely differing forms. They are divided among the different tribes as follows: in the Fevilleae, *Fevillea cordifolia* L.; in the Melothrieae, *Melothria pendula* L., *Apodanthera undulata* Asa Gray; in the Cucurbiteae, *Momordica Charantia* L., *Luffa acutangula* (L.) Roxb., *Citrullus Citrullus* (L.) Karst. (*Citrullus vulgaris* Schrad.), *Cucumis myriocarpus* Naud.,

Bryonopsis laciniosa erythrocarpa Naud., *Benincasa hispida* (Thunb.) Cogn., *Lagenaria Lagenaria* (L.) Lyons (*Lagenaria vulgaris* Sér.), *Trichosanthes Anguina* L., *Cucurbita Pepo* L.; in the Sicyoideae, *Coccinia cordifolia* (L.) Cogn., *Micrampelis lobata* (Michx.) Greene, *Sicyos angulata* L.; in the Cyclanthereae, *Cyclanthera explodens* Naud.

Organogeny of the gynoecium

The form, size and structure of the ovary varies much in the different genera and species. The ovary, in all cases inferior, may contain one seed, as in *Sicyos*, or many, as in *Cucurbita*, distributed in various ways presently to be described.

As early as 1682 Nehemiah Grew[30] in his Anatomy of Plants described the structure of the ovary and the manner of placentation in *Cucumis sativus*. He says, "The middle parenchyma is divided into three columns which stand triangularly, having each of them a triangular figure." "These columns are, as it were, beds on which the seeds grow." He found the ovary divided into six triangles and each triangle to contain three "ovals."

Gaertner[25] more than one hundred years later described and figured the more obvious structural features of the seeds and ovaries of *Sicyos*, *Bryonia*, *Momordica*, *Cucurbita*, *Cucumis* and *Lagenaria*. His figures, though not very clear in all points, show very well the divisions of ovary and the parietal attachment of the seeds in *Cucumis* and *Cucurbita*.

In 1815 Mirbel,[59] in describing the form of fruit known as a pepo refers to the structure of the ovary of the Cucurbitaceae. His reference is particularly to *Cucurbita* and *Cucumis*, and he states that the ovary is divided into many locules by radiating placentae, the lobes of which are bordered by nerves which bear the ovules, the latter being borne in two ranks on each lobe. In some cases, he points out, locules are divided each by a pulpy wall.

Brongniart[8] (1826) described the anatomy of the ovary of *Cucurbita Pepo* with special reference, however, to the con-

ducting tissue. He regarded the ovules as being borne on the edges of the carpels, and in general as representing the teeth of the leaves.

Coming down to the more recent work of Eichler[21] (1875) we find a discussion of the relations of the parts of the flowers of both kinds. The ovary of *Cucurbita* is divided into three parts, or four or five parts, representing as many carpels. The edges of these carpels are turned inward, meet at the center of the ovary and are flexed back toward the outside again lying one beside another, and these reflexed margins form the placentae. The stigma which surmounts the ovary has lobes equal in number to the carpels and standing opposite to them. He represents the placental folds as being separated by a false commissure, evidently formed by the reflexed laminae of the carpellary leaves.

Ecballium agreste and *Bryonia dioecia* show a lesser development of the carpellary margins so that the commisural partitions are not so complete. The pistillate flowers of *Sicyos* are often on the tetramerous plan, probably by reduction from the pentamerous form (as in certain of the Plantaginaceae), by abortion of the calyx-lobe next the axis and the fusion of the two nearest corolla-lobes. From the fact that the stigma is divided into from three to five lobes, he regards the ovary as composed of the same number of carpels, but is uncertain whether to regard the lobes as representing the middle of the carpels or their borders.

Müller[64] (1889) refers largely to Eichler's work in discussing the floral structures. He points out the principal features in the structure of the ovary, and shows that the three principal partitions in the ovary of most of the Cucurbitaceae are the infolded margins of the carpels which grow back toward the wall of the ovary again after reaching the center, thus forming the placenta. This is shown in pistillodia, which show different stages in this process of development. He considers the original ovary to have had five locules, but the prevailing type has three. Each carpel is surmounted by a two-lobed stigma, but these lobes fuse often with the

adjacent lobes of other carpels and thus the true stigmatic lobes stand opposite the partitions and not opposite the carpels.

The observations upon the development of the gynoecium of the Cucurbitaceae, as about to be described, have been carefully made by means of microtome sections of the growing tips of the flowering shoot. The serial sections prepared have afforded a means of comparison of the different stages of growth quite satisfactory.

Fevilleae

The apex of the stem of *Fevillea* presents a dome-like form and in longitudinal section shows its epidermal and subepidermal cells in regular series lying in "confocal parabola" as Strasburger[79] describes for *Polygonum divaricatum*. The regularity in the arrangement of the cells is maintained to three or four layers below the epidermis. Slightly below the apex of the stem in the axil of a leaf-rudiment may be found the primordia of the young flowers. A blunt outgrowth may here be seen, which in the progress of its growth soon loses all trace of the confocal arrangement of its cells, and by numerous divisions, longitudinal with reference to the axis of the flower, becomes flattened at the apex and broadens out like the base of a cone. Around the border of this body, in a slightly later stage, five slight elevations may be detected which become quite distinct before any other organs are differentiated. Figure *5* (Pl. I) shows the young floral rudiment, with two of the five young calyx-lobes, bent sharply over the flattened end.

Goebel[29] describes the development of the gynoecium in *Epiphyllum truncatum* which, he declares, is in the fundamental points the same process of development as that which is to be observed in all inferior ovaries. In *Epiphyllum* the calyx and corolla arise in spiral order but before they are all laid down the flattened end of the axis shows a crater-like deepening, from the borders of which the carpels spring and grow up to form the style. The placentae are developed as

swellings where the edges of the carpels meet. In *Fevillea* the case is practically the same. After the differentiation of the five outer lobes, there arise on the border of the disc-like area, which they surround, five other lobes alternate with the first and subsequently five other elevations may be noticed opposite the calyx-lobes. These represent the staminodia and for a time they resemble the young corolla-lobes. Soon after these lobes become distinctly visible, the deepening of the central area takes place and the carpels appear as slight elevations on the sides of the concavity (*fig. 6*). The number of carpels constituting the gynoecium of *Fevillea* is three; the number of the calyx and corolla-lobes is five: hence a carpel may sometimes be opposite a lobe of the corolla sometimes on a radius between two. Figure *6* shows the origin of one of the carpels as seen in a longitudinal section of a flower in the stage of development just referred to. The carpel in this case appears to originate in a slight elevation of cells between the corolla-lobe and the bottom of the depression. As growth proceeds the cavity becomes deeper, the carpels and the corolla-lobes stand free as eight papilla-like bodies on its border. In the open pistillate flower of *Fevillea* the summit of the ovary is about 5 mm. in diameter and forms the floor of the flower from which the short styles emerge separately and bend outward. The placentae are first noticeable as small vertically running ridges between the incipient carpels, that is the point at which we may conceive the edges of the carpels as uniting. These ridges grow in toward the center of the cavity and meet first in the upper part of the ovary (*fig. 7*) and thus close the cavity. The placental ridges meet later in the lower part but between them there are maintained three spaces in which the ovules are freely suspended until some time after fertilization, when the growth of the seeds and the expansion of the tissue of the pericarp invests them with the pulpy tissue. When the ovules first appear on the placenta they stand out at right angles to the axis but later they become pendent and flexed back along the sides of the dissepiments. Ordinarily two or

three ovules are borne on each lobe of the placenta, making about twelve or fifteen in each ovary.

Melothrieae

The pistillate flower of *Melothria* arises as a lateral outgrowth similar to that of *Fevillea*. It is at first rounded at the apex, but soon becomes flattened and concave. About as soon as the depression becomes distinctly discernable, five lobes appear upon its border, and these increase rapidly in size and soon overtop the concavity. By this time there have arisen, alternately with these lobes, five others on the inside of the cup and just below the insertion of the outer circle. (*fig. 1, C*). This figure also shows the beginning of the staminodia which here appear as slight elevations below the second circle of protuberances. The placentae appear in figure *1*, *D*. Up to this time, and much later, in fact, there is little or no growth of the central tissue of the axis. After the first circle of lobes appears there is an increase in the growth of the outer tissue, which becomes often clearly marked off from the more central tissue by reason of its larger cells. The growth of this outer layer carries up with it the younger lobes so that they appear later to be an outgrowth of its inner surface. The most rapid zone of growth is just below the second circle of lobes or the corolla-lobes, so that the calyx and corolla soon become lifted above the young placental lobes. Later another zone of elongation is to be seen below the first placental lobes, so that the latter become considerably removed from the bottom of the cup, and finally grow up into the style and stigma. The first series of lobes formed gives rise to the calyx.

After elongation in the second zone has proceeded for some time the longitudinal ridges of the placentae appear, three in number reaching to the bottom of the cup. These grow in toward the center, become later angular by reason of mutual pressure and each bears two rows of ovules, which finally assume an anatropous position with the micropyle directly toward the wall of the ovary.

Cucurbiteae

In the development of the pistillate flowers *Bryonopsis* displays in its earliest stages the same features as those which characterize *Fevillea*. A lateral outgrowth becomes flattened at the end and soon the flat surface becomes concave. Almost as soon as the concavity is perceptible the origin of the parts of the floral envelope are manifest. Five lobes arise in an outer circle, and these lobes are alternate with five others in an inner circle. At this time inside of the inner circle of organs there is but a very slight concavity and no appearance of carpels or staminodia.

In the formation of the placenta *Bryonopsis* resembles *Fevillea*. Three ridges arise in the concavity and traverse its sides vertically at equidistant points. These ridges soon meet at the center and ultimately fill all the cavity except three narrow spaces running out from the center laterally. The placental folds simply come into contact but do not fuse. As growth proceeds in the placenta and in the outer tissue of the ovary it is retarded in those parts which might be considered the bases of the longitudinally running ridges. The three radiating narrow spaces between the placentae now become expanded at the outer border so that the ovary in transverse section appears to be divided internally into three parts by radiating fissures with a T-shape extremity. This is the beginning of the formation of the free ovule-bearing edge of the placenta. These ovule-bearing edges lie in the angles of the T. This modification of the internal structure is confined to the central part of the ovary and does not extend upward through the style. A triangular passage-way is, however, maintained through the style to the stigma, thus providing an open stylar canal.

The angular borders of the placenta soon show a condensation of the protoplasm of their constituent cells, followed by the appearance of the ovules as slight swellings along the borders. Only one row of ovules is developed on each lobe of the placenta, so that in any transverse section of the ovary it would not be possible to find more than six ovules.

Only when the ovules are quite young is one likely to find as many as six, owing to the fact that the subsequent growth and elongation of the ovary disturbs somewhat the original uniform order, and the requirements of space render necessary a more economical arrangement, which is attained by the overlapping of the seeds of contiguous placentae, which takes place to some extent. The position which the ovule ultimately assumes is one in which its axis is coincident with a radius and its micropyle is directed outward. In the earliest stages of the ovule its axis lies at right angles to the radius which passes through its center. In the process of growth the apex of the ovule is soon directed toward the center of the ovary and finally toward the periphery so that the apex describes during its growth an arc of 270°. Unlike the ovules of *Fevillea*, those of *Bryonopsis* remain essentially perpendicular to the axis of the ovary, a condition to be found in most of the Cucurbiteae.

The process of development runs about the same in other members of this tribe. The cup-like depression appears in the young flower on the inner surfaces of which three inwardly projecting ridges meet in the line of the floral axis and produce the placental folds on the right and left sides of each ridge. While one finds in *Bryonopsis*, *Trichosanthes* and *Momordica* a single line of ovules in each placental border, the case is different in *Citrullus* and *Cucurbita*. In these genera what was originally a single placental border, has become doubled or trebled so that there are two or three longitudinally running ridges in each plant instead of one. Consequently a transverse section of the ovary shows a series of ovules of different sizes borne on each reflexed margin of a carpel. The ovules are smallest near the margins of the carpels, and largest always on the portion of the placenta nearest its origin. Between these two extremes a gradual progression in size is maintained, the internal development and differentiation of the ovule keeping pace with its outward development. The difference in size is lessened, however, by the time the flower opens, so that the opportunities for fertilization

are about equal so far as the degree of development is concerned. *Cucumis* does not show the same degree of difference in the development of the placenta and ovules which is characteristic of *Cucurbita* and *Citrullus*. A transverse section of the developing ovary shows fewer ovules and these more equally developed, and more uniformly placed with reference to the radii of the section.

In *Luffa* the pistillate flowers are early differentiated from other lateral outgrowths by the usual features. Sepals, petals, staminodia and carpels may all be recognized in the longitudinal section of a young flower. Such a section through an ovary about one mm. in length shows the incipient style and the downward prolongation of the placental lobes below the region of their origin. This prolongation may be one and a half times the length of the stylar canal at this stage. When the ovary has attained the length of three mm., slight elevations along the placental borders mark the origin of the ovules, which later appear in two ranks on each border. The stylar canal does not elongate in a proportional rate with the other structures, for in an ovary of this size it is barely one fourth of the length of the lobes of the placenta. The ovules gradually turn the micropyle toward the periphery of the ovary, but by the time the megaspore has undergone division the funicle of each ovule has become much elongated. The ovules show an unequal rate of development, those on the proximal portions of the placenta being farther advanced than are those on its extreme borders.

Benincasa and *Lagenaria* exhibit features in the development of pistillate flowers similar to those of *Luffa* and need not here be described in detail. In these, however, the placenta bears several rows of ovules instead of two as in *Luffa*. The ovules are much like those of *Cucumis*, borne on an elongated funicle. In other respects, however, they are much like those of most other members of this family, possessing a broadly conical nucellus, with outer integument strongly developed and the inner one hardly visible except in younger stages.

Sicyoideae

In the Sicyoideae, the distinguishing characters of which are to be found mostly in the androecium, one is impressed by the variations in the forms of the pistillate flowers. *Coccinia* presents a case in which the structure of the ovary is not essentially different from that of some of the Cucurbiteae. Not only are the developmental features similar, but one finds in a transverse section of a young ovary that it is distinctly tricarpellary, and furthermore, that on each placental border, not one only, but two rows of ovules are present. This condition is quite different from that which is to be found in other members of this tribe, viz., *Sicyos* and *Micrampelis*.

The pistillate flowers of *Sicyos* are borne in dense clusters, several flowers being sessile at the end of a common peduncle. Sections of the growing tip of a flowering shoot pass through several of these clusters at various stages of development. As the flowers project in all directions from the end of the peduncle, it follows that they appear in the preparation sectioned in many different directions. The pistillate inflorescence first appears near the growing point of the shoot in the form of a blunt outgrowth in the axil of a leaf-rudiment. This outgrowth soon develops on its surface numerous papilla-like elevations which continue to increase in height. These are at first rounded at the end, but later the end becomes flattened perpendicularly to the axis. This flat surface becomes later depressed at the center by reason of the more rapid growth in the peripheral region, and the depression gradually deepens into a cup. About the time the depression has reached a depth a little greater than the transverse diameter of the ovary, the corolla-lobes appear near the top in a circle running parallel with the upper border and on the inside. This is followed a little later by the appearance of three elevations a little lower down and also in the inside. As growth proceeds the border or rim of the cup becomes divided to form the calyx and the next circle of organs forms the corolla. The three outgrowths which arise

from near the bottom of the cup give rise to the gynoecium. They grow in toward the center until they meet and then become prolonged upward to form the style and stigma. From one of these outgrowths a small elevation may be early distinguished, which marks the rudiment of the ovule. This elevation bends down toward the base of the ovary and soon fills the cavity of the ovary before there is any differentiation of integuments. By the time the cavity of the ovary is filled the young ovule is a downward projecting lobe and about the time that the integuments are first distinguishable it begins the turning which finally brings it to the anatropous position. The turning takes place toward the side on which the ovule had its origin, the apex of the nucellus being turned underneath and finally brought up toward the placenta, so that its final position is anatropous, with the micropyle directed toward the style. The single ovule entirely fills the ovarian cavity, but it is at all points separate from the wall except at the placenta.

The development of *Micrampelis* presents some very interesting differences from the foregoing types. The pistillate flowers are borne singly and each normal ovary contains four seeds. In the mature fruit the micropyles of the ovules are directed toward the base of the ovary, the opposite, in this respect, of *Sicyos*. The earlier stages in the development of the ovary resemble those of *Sicyos*, in the manner of the formation of the cup and the development of the two apparent rings inside the cup. The upper ring grows upward forming style and stigma, as in *Sicyos*. The lower ring becomes modified in a very different way. The ovary here is evidently composed of two carpels and the inflexed borders of these carpels as usual become the placentae. What appears to be a ring is not actually such but opposite elevations which mark the edges of the carpels and which are more or less convergent horizontally. These elevations appoach from opposite sides and flatten against each other at the center, so that two lobes are formed each provided with two wings. On the lower portion of each wing an ovule arises in the

usual manner. The apex of the nucellus is at first directed downward but gradually turns toward the axis of the ovary. The turning continues so that the micropyle is at one time directed toward the axis, later upward, and finally downward again by continuous turning in the same direction. As in *Sicyos* the cavity of the ovary is very early filled by the growing tissue and the ovules, but here also the stylar canal is maintained. While the turning of the ovule is taking place a torsion of the funicle is also going on so that the raphe instead of lying on that side of the ovule which is toward the median line of the carpel, is on the side toward the line of union of the carpels. The placentation, which is at first apparently basal and later central, is in reality parietal and essentially similar to that of the other types already considered.

Cyclanthereae

Near the growing point of the shoot, in *Cyclanthera*, there arise lateral protuberances (leaf-rudiments), and in the axils of these outgrowths other lobes appear which are the primordia of the inflorescences. The division of the axillary lobe into lesser lobes is soon apparent. One of these becomes a pistillate, the others all staminate flowers. The difference between the two can early be recognized. Both at first are flattened across the apex, but soon the staminate flowers are marked by a convexity within the circle of corolla lobes, while the pistillate flowers become more concave. In the pistillate flower this concavity deepens and the placenta appears as a broad ridge inside running parallel with the axis of the flower. This placental ridge soon fills the cavity and bears from ten to fifteen ovules in two lateral rows. The stylar canal, easily discernible in the earlier stages, is practically obliterated at the time of the fertilization. At this time the ovules stand almost perpendicular to the axis of the ovary with the micropyle directed outward near the line of union of the carpel-borders.

Embryo-sac

Fevillea

The first indication of the appearance of the ovules upon the placental folds may be noted at the time when the young pistillate flower is slightly less than 1 mm. in length. Slight elevations along the reflexed margins of the carpels indicate the positions of the individual ovules. At this time the whole placental region shows distinctly the characteristics of meristematic tissue. As Warming[86] has shown, the growth of the ovular "Anlage" proceeds by the division of subepidermal cells, and he has pointed out that in some these divisions occur chiefly in those cells situated immediately below the epidermis, and in others in the third layer of cells, or the second below the epidermis. Among the Sympetalae the former type is represented by *Senecio*, the latter by *Symphytum*, *Verbascum*, *Lamium* and others. A section through the ovary of a very young flower of *Fevillea*, before there is any indication of the formation of ovules, shows that the multiplication of cells is chiefly in the region several layers of cells deep under the epidermis. There are no very regular subepidermal layers of cells at this period, divisions occurring in different planes. The divisions, however, predominate in the plane tangential with reference to the ovary wall, so that the central region of the placenta shows radiating rows of cells which flex to right and left toward the borders from which the ovules arise. When, however, the formation of ovules begins to be evident, a layer of subepidermal cells of considerable regularity is noticeable, and divisions occur abundantly in this layer as well as in the epidermis in a radial direction. Sometimes the second and third layers assume a degree of regularity, all of which is merely an expression of the direction of growth at this time. The subepidermal layer remains distinct for some time while divisions of its cells are taking place in radial planes. Even after tangential walls are formed in these cells, the limits of the original subepidermal layer are still apparent in the older and thicker walls which

toward the outside separate it from the epidermis and toward the inside from the more deeply lying tissue. The first tangential walls may be formed in this layer at the apex of the nucellus.

The first suggestion of the origin of an integument is to be seen in the enlargement radially of the cells of the epidermis at two points, as appears in section not far removed from the apex of the nucellus. This collar-like growth is next augmented by a tangential division of the epidermal cells at its summit and later by the divisions of those beneath. The inner integument is clearly to be recognized before the outer one and rises above the nucellus as a thin collar two layers of cells in thickness and divided entirely from the epidermis. By the time that the inner integument has formed a distinct ridge around the young ovule, the expansion of the mass of tissue at its base denotes the beginning of the outer integument. The growth of this integument soon exceeds that of the inner and before there has been much differentiation of structures within the nucellus it has far overtopped the inner integument and the nucellus. The ovule, in regard to the relative size of its different vegetative parts, is unlike that of other sympetalous flowers (Boraginaceae, Labiatae, Scrophulariaceae, Valerianaceae, Compositae), in which there is a reduction of the nucellus and inner integument. In its earlier stages especially it bears far more resemblance to those of some of the Choripetalae (Rosaceae, Geraniaceae) than to those of other groups to which the Cucurbitaceae are regarded as more closely related. Figure *13* shows the relative development of the different parts of the ovule. The integuments present the rather unusual appearance of being much elongated and standing free for a considerable distance above the nucellus. The micropyle is a wide canal up to the time of fertilization and up to this time the inner integument is always distinct from the outer. Soon after this period, however, when there is the most rapid development of structures within the nucellus, it becomes almost obliterated at the sides of the nucellus, though plainly visible toward the

chalaza and at the micropyle. In the latter place it has practically filled the micropyle by a proliferation of cells on its inner surface. At about the time of fertilization the outer epidermis of the outer integument begins the tangential divisions which, as Harz[37] has described for other Cucurbitaceae, give rise to the characteristic histological features which are well known in the ripe seeds of this family. Subsequently to this period, growth in the ovule is principally in the outer integument, the nucellus enlarging mainly by the expansion of cells already formed.

When the first periblem layer in the very young ovule has assumed some degree of regularity, a cell situated immediately below the epidermis at the apex of the young nucellus increases in size and becomes clearly differentiated from its neighbors (*fig. 9*). The first division of this cell is tangential and a single tapetal cell is cut off. The inner daughter-cell, the megaspore-mother-cell, remains undivided and enters upon a period of growth. The tapetal cell in the meantime divides by walls both perpendicular and tangential to the epidermis, so that the spore-mother-cell soon becomes covered by a row of cells to the number of ten or twelve. At this time divisions are going on in the cells to the right and left of this row so that several rows of cells are formed and the appearance is such as is shown in figure *12*.

Both first and second divisions of the spore-mother-cell were observed. Four spores are formed, but only the lowermost one is functional. The four megaspores were sometimes observed soon after the division when they were all in good condition and again when the three uppermost ones were beginning to disintegrate (*fig. 16*). In figure *16* the two upper cells appear a little more advanced in the process of disintegration than does the third cell. Usually light walls are formed between the potential megaspores, but sometimes none are formed in the first division. It might be inquired as to whether this condition does not represent the second division of the megaspore rather than the second division of the megaspore-mother-cell. It may be answered

that such can hardly be the case, inasmuch as no potential megaspores were observed nor any cells that could be taken as such, upon this assumption. The division into four megaspores occurs with so great a regularity in this type that there is hardly a chance for such an error.

The functional megaspore enters upon a period of enlargement and divides to form the embryo-sac in the usual manner. The definitive embryo-sac is smaller than that found in some of the other genera. As the fixation of the material in the definitive embryo-sac stage was not very good, no description of its minute structure will be attempted. It presents about the same general features as are found in the embryo-sacs of the other genera studied. The endosperm nuclei fuse before fertilization. The antipodal cells are noticeable only for a short time. The egg-apparatus consists of two synergids, pyriform, vacuolated, with striated hyaline upper portions and a centrally situated nucleus. The oösphere as in other cases presents a much vacuolated appearance in its upper portion and a small nucleus embedded in the thicker protoplasm of its lower portion.

Preparations showing the process of fertilization were not secured. Some preparations showing young embryos were obtained, however, and the embryos appear to differ a good deal from those of the other genera. A small mass of cells is to be seen lying close against the tissue of the nucellus in the embryo-sac. The divisions have produced an embryo of about ten to twelve cells, of which a part are shown in figure *20*. The first cleavage-planes could not with certainty be determined in this case, but they are apparently transverse.

In the case represented by figure *24* the cell-formation of the embryo is quite regular, but in most cases the embryo consists of a rounded mass in which no definite system of cleavages is apparent (*figs. 20* and *22*). In figure *20* the line *ab* appears to represent the oldest cleavage-plane, as it is the thickest of the walls there apparent. But in this case no suspensor appears; which is the condition in the majority of the Cucurbitaceae. Later embryonic stages were not ob-

served. The endosperm is only a very thin peripheral mass, at the time in the development of the embryo indicated by figure *21*. Its nuclei are very small and are not clearly distinct, but are thickly scattered through a densely granular protoplasm. The cavity occupied by the embryo-sac rapidly expands after fertilization and the endosperm remains closely applied to its periphery. At the micropylar end the cavity is oval, narrowing quickly to a narrow tube which stretches toward the chalaza, the tissue of the nucellus disintegrating before it.

Melothria

The ovule originates in *Melothria* as a rounded elevation on the right or left flank of the placenta. By growth of the hypodermal cells at the apex of this elevation, its cells are brought into a serial arrangement in rows running back toward the base of the rudimentary nucellus. The spore-mother-cell apparently originates in this form as in *Fevillea*. The earliest stage observed is represented by figure *25*, which shows the relative size of the spore-mother-cell and its relation to other parts of the young ovule. While the subsequent stages of development were not fully represented in the preparations obtained, enough was observed to give a more or less adequate idea of the course of development.

About the time when the spore-mother-cell appears, the ovule begins to turn toward the placenta and the inner integuments begin to show. At this time the apex of the nucellus is directed toward the center of the ovary, thus having its long axis coincident with a radius. When the embryo-sac has reached the four-celled stage as shown in figure *26*, it has turned to a position at right angles to a radius. Numerous preparations showing four cells in the embryo-sac were obtained, but in none of these was there any evidence of degenerated potential megaspores. If such structures were present they must have disappeared early. By the time the embryo-sac has become ready for fertilization the micropyle is directed outward. The embryo-sac in all stages in *Melothria* is very minute and does not lend itself to the study of

more than its grosser morphological features. It consists (*fig. 27*) of an egg-cell, two synergids and two polar nuclei, at a time when the pollen-tube can be detected in the tissue just outside the micropyle. The synergids are long, narrow and vacuolated in their lower portions. The egg-cell is relatively large, but consists of only a thin protoplasmic sac with the nucleus at the lower end. The polar nuclei are largest and surrounded by a dense mass of protoplasm. No antipodals could be found.

Several stages in the development of the embryos were observed. The earliest walls found are transverse, but these are soon succeeded by longitudinal divisions (*figs. 28–31*), first in the distal cell of the series, and later in the short or rudimentary suspensor. The cells of the suspensor are never many, and the few that are formed are soon disorganized (*figs. 30, 31*). The first cleavage of the proembryos are quite regular (*fig. 31*), but the subsequent divisions are in no definite order, and a globular mass of cells is soon formed (*fig. 32*) in which no differentiation is apparent except that the epidermis is clearly defined and remains so. A beak-like prolongation in the proximal portion indicates the slight suspensor, which is not always connected with the wall of the embryo-sac cavity; the embryos usually appearing to be free in the micropylar end of the cavity. The spherical form of the embryos is maintained until they reach a size visible through an ordinary hand-lens. An elongation of the mass then begins and the cotyledons soon appear as two lobes at the distal extremity (*fig. 33*). In the next later stage observed the cotyledons had assumed the proportions indicated by figure *34*. Still no differentiation of periblem and plerome could be detected, but the initial stages in the formation of the root-cap were visible.

The endosperm begins to form early after fertilization. The complete fusion of the polar nuclei was not observed, but if it occurs it must be at about the time of fertilization. By the time the first cleavage of the embryo has been completed, the endosperm has formed a thin sac which rapidly

displaces the surrounding tissue of the nucellus. As the cavity in the nucellus expands the endosperm keeps pace with it, forming always a thin layer closely applied to the sterile tissue. The displacement of the tissue of the nucellus, however, is mainly in the direction of the chalaza, and even when the embryo is comparatively small (*fig. 32*) the nucellus is penetrated by a thin string of endosperm which reaches almost to its base. When the embryo is older (*figs. 33, 34*) this string of endosperm becomes more evident, but the lateral tissue of the nucellus, that is the tissue along its sides, is only slowly dissolved. The nucellus and in fact all parts of the ovule enlarge rapidly, so that at the stage of embryonic development represented by figure *32*, which is comparatively early, the ovules have already enlarged to many times their size at the time of fertilization, and the outer integument has already undergone considerable modification in the way of thickened cell-walls.

Apodanthera

The material available for the study of this form was somewhat fragmentary, consisting mainly of fruits and seeds in rather advanced conditions. The early stages showing the development of the gynoecium and the origin of the sporogenous tissue were entirely lacking. Figures *35–43* represent fairly well the conditions observed in this material, which include mature embryo-sacs and embryos in various stages of development.

The development of the ovary in *Apodanthera* appears to conform to the usual type so far as could be determined from the material at hand. Each placental flank bears a row of ovules which at the time of fertilization lie with their micropyles directed outward. At this time the placentae have entirely fused where they come into contact at the center. The ovules at this stage are nearly circular in longitudinal section, the outer integument being thick (about one sixth the diameter of the ovule), while the inner integument is but a thin layer, two or three cells in thickness.

The embryo-sac at the time of fertilization occupies but a small oval space near the micropyle. At this stage it consists of the usual structures though with certain individual characteristics worth noting (*fig. 35*). The most conspicuous element of the embryo-sac is its endosperm nucleus. This is relatively large; it is marked also by its chromatin content and large nucleolus. The cytoplasm surrounding the nucleus is quite dense and radiates from the center in strands separated by numerous vacuoles. The egg-apparatus in its general form and structure conforms to the types already described. The nuclei and the vacuoles of the synergids are quite small as compared with those observed in some of the other forms. In this case antipodals were observed, though only as vestiges (*fig. 35*).

Immediately after fertilization certain marked changes may be seen in the character of the embryo-sac. It expands, much as in other cases, into a sac-like structure, but soon becomes filled with numerous refractive starch-grains, among which occasional free nuclei are easily seen (*fig. 36*). The nuclei and the starch-grains are both more abundant in the upper portion of the embryo-sac. The nuclei have lost some of the features which characterized the original endosperm nucleus, being here almost devoid of any chromatic substances, aside from the large nucleolus. The starch which forms so conspicuous a part of the endosperm is, however, of only transient duration. The endosperm expands rapidly toward the chalaza and laterally and soon becomes a thin layer of vacuolated protoplasm, in which the nuclei are still free. The starch at this stage (*fig. 39*) has entirely disappeared. The lower extremity of the endosperm soon assumes the appearance of a haustorium. In this condition it appears as a finger-shaped, vacuolated mass, containing several nuclei (*fig. 39*), before which the tissue of the nucellus breaks down. This appendage, however, disappears in the course of development (*fig. 41*), but in the case just cited the nucellus presents no further obstacle to the development of either endosperm or embyro. At this stage the endosperm

has become entirely cellular, a mass of loose tissue whose outer surface is composed of a layer of cubical or tabular cells.

The embryo does not materially differ from those of several other forms examined. An earlier stage than that represented by figure *37* was not observed. Here can be seen a short suspensor with some longitudinal divisions and the epidermis marked off to some degree. The subsequent growth of the embryonic mass results in the assumption of a pyriform shape, which gradually gives way to a more rounded form. The cotyledons appear at a slightly later stage, when the distal portion of the mass becomes somewhat flattened. The differentiation of structures at the apex of the radicle does not appear, however, until some time later, as shown in figure *42*, in which the root-cap and dermatogen may be distinguished. At the stage represented in figure *39* the form of the ovule is materially changed. It elongates rapidly during this period and when the early embryonic differentiation appears (*fig. 43*) has practically assumed the proportions of a ripe seed.

Bryonopsis

In the case of *Bryonopsis* there arises a single row of ovules upon each flank of the placenta. Beneath the apex of the incipient nucellus the spore-mother-cell may be found at an early stage. Although an entirely complete series of the early stages was not obtained, the conditions that were observed indicate that the spore-mother-cell arises in the usual way. In the earliest stage observed but two tapetal cells were found separating the mother-cell from the overlying epidermis. Figure *44* shows a condition slightly later. About this time the inner integument may be detected arising from the epidermis in a ring below the apex of the nucellus.

By the periclinal divisions of the tapetal cells and those adjoining, the spore-mother-cell soon becomes centrally situated in the nucellus (*fig. 45*). It also becomes considerably elongated and soon divides into four megaspores of which the lowermost is the functional one (*fig. 46*). The three

upper cells disorganize and may be seen in later stages as a dark mass overlying the young embryo-sac (*fig. 47*). The development of the parts of the ovule keeps pace with that of the internal structures and when the condition represented by figure *46* is reached, the inner and outer integuments have overtopped the nucellus, the former thin and composed mostly of two layers of cells, the latter thick and showing some differentiation of vascular tissue.

An embryo-sac of two cells is shown in figure *47* and another of eight cells in figure *48*. In the megaspore (*fig. 46*) the nucleus is more prominent than in any of the subsequent stages, and as growth of the cell proceeds, vacuolization follows to a large extent. After the first division the two resulting nuclei are separated to opposite ends of the embryo-sac by the large vacuole (*fig. 47*), and the nuclei resulting from subsequent divisions are similarly disposed (*fig. 48*). In the preparation represented by figure *48* the earlier steps in differentiation were visible. The synergids, oösphere and upper polar nucleus were easily discernible. In the antipodal region not so much difference was visible but the polar nucleus appears the most conspicuous of them all. The definitive embryo-sac has some characters in common with those previously described. The synergids are slender, pointed at the upper ends and vacuolated in the broader, lower portion. As in other cases the upper portion bears a hyaline striated aspect. The oösphere is somewhat more conspicuous than in many other cases and the polar nuclei less so. The antipodals remain quite evident up to this time. Figure *49* represents a condition in which the polar nuclei are in contact but not united. The complete fusion of these was not observed. At the stage represented by figure *49*, which is prior to fertilization, the embryo-sac is packed with starch which persists until some time after fertilization (*fig. 50*).

The ovule at the time of fertilization is oblong in form, its length being approximately three times its broadest diameter. Not until fertilization has been accomplished is the

growth very rapid. Then, however, it expands rapidly, its growth in length being considerably greater than that in breadth. The embryo-sac, at the time indicated by figure *49*, occupies the center of the upper half of the nucellus, the cells immediately surrounding it appearing somewhat crowded or compressed. After fertilization, however, this tissue at once gives way before the expanding endosperm. The tissue surrounding the embryo-sac now colors a little more deeply when the preparation is stained. While growth in length is proceeding rapidly the nucellus becomes cleft from apex to chalaza, though apparently due to the tension of growth in its peripheral region and not to any influence of the endosperm.

The endosperm, after fertilization of the oösphere, soon becomes distributed peripherally (*fig. 50*), and forms an exceedingly thin layer for some time. The starch may still be found in simple and compound grains distributed irregularly in this layer of protoplasm. During this period the nuclei increase considerably in size, as can be seen by a comparison of figures *49* and *50*, which were drawn to the same scale. At this time the endosperm is non-cellular, but the nuclei soon become separated by walls throughout, and in its upper portion it appears as shown in figure *51*, at which stage all traces of starch have disappeared. The cells of the endosperm are most compact in its outer portion, those more centrally situated possessing only a thin layer of cytoplasm which lines the cell-wall.

Only two conditions of the embryo were observed in *Bryonopsis*. After fertilization the oösphere enlarges to a considerable degree before dividing (*fig. 50*). The earlier cleavages were not discovered in any of the preparations, but a later condition (*fig. 51*) was found which shows the embryo to be at one stage almost spherical in form with no visible suspensor. No differentiation of structure is apparent at this stage except the epidermis. From this condition it may be inferred that the differentiation of form and structure proceeds in this form about as in some of the other types described. In view of

the ephemeral character of the suspensor in the other forms it is quite possible that such a structure may be formed here, but later lost. Cell-division at this stage proceeds at random and only at opposite ends is there any apparent regularity in the sequence of the cell-divisions. Cells at the proximal end appear at this stage to initiate the process by which the root-cap is differentiated, and at the distal end to form in that order which, in later embryos, shows them arranged in layers parallel with the epidermis.

Trichosanthes

Trichosanthes presents certain features which quite strongly suggest those found in *Bryonopsis*. In the origin of the ovule upon the placenta the conditions are quite similar, each flank of the placenta bearing a single series of ovules. The first indication of the formation of sporogenous tissue may be seen when the ovule is still merely a small elevation on the placenta. At this time the archesporium, consisting of a single cell, appears immediately below the epidermis at the apex of the young nucellus (*fig. 52*). It may readily be recognized by the usual characters which mark sporogenous tissue. At this stage no differentiation of the ovule is apparent, but its rapid growth results in the distribution of its cells in confocal series as seen often in longitudinal section of the organ.

The hypodermal archesporial cell divides to form the tapetum and the spore-mother-cell. The former continues to divide by periclinal walls, thus forming an axial row of from ten to twelve cells. The sporogenous cell enlarges in the mean time, acquiring a nucleus which occupies most of the space within the walls of the cell (*fig. 53*). The process of spore-formation appears to be quite regular in *Trichosanthes*, that is the functional megaspore is one-fourth the spore-mother-cell. The first division results in the formation of two cells, of which the outer one, however, does not again divide. It immediately disorganizes, while the other cell, the lower of the two, proceeds to divide again transversely. The spindle

of the division may be clearly seen, while the adjoining cell is in the process of deterioration (*fig. 54*). The outer cell resulting from the second division also disorganizes, so that the functional cell is the lowest of the series (*fig. 55*). In this case the remains of the discarded cell from the first division are still visible.

It is quite probable that the development of the embryo-sac from the spore thus formed proceeds in the usual manner, though some of the steps were not observed. The definitive embryo-sac is represented by figure *56*. In this case the egg-apparatus presents the usual features. The synergids are rather more conspicuous than in the preceding form (*fig. 49*), and the oösphere less so. The antipodals are large and stain deeply, though the latter fact is apparently due to their partially disorganized condition. The endosperm nucleus is formed by the union of the two polar nuclei, though the two larger nucleoli thus contributed remain distinct, so far as it was possible to observe. The embryo-sac at this stage does not present the much-vacuolated appearance which was characteristic of some of the foregoing forms (*Apodanthera*), but instead is very compact and like that of *Bryonopsis* is filled with starch. This starch is conspicuous in the embryo-sac until after fertilization and then soon disappears (*fig. 57*). At this time the embryo-sac begins to expand and the surrounding tissue is affected for some distance, as indicated by its staining properties. As appears in some of the cases already described, the endosperm becomes modified in character as the embryo begins to form. It not only loses its starch but becomes distributed as a very thin sac closely approximated to the rapidly receding tissue of the nucellus. The nuclei are at first free in the endosperm and irregularly distributed through it. They are not nearly so conspicuous in size and chromatic content as was the original nucleus. In a still later condition of the endosperm the nuclei enlarge somewhat (*fig. 60*), but it is to be noted that with the progress of development the nucleoli constantly diminish in size. The endosperm has become entirely cellular before the embryo

has reached any considerable degree of development (*fig. 59*). A few cells from the upper end of this mass are shown in detail (*fig. 60*). In these the scant cytoplasm is a very prominent feature.

The embryo proceeds from a fertilized oösphere, presumably. The process of fertilization was not observed, but conditions in the embryo-sac appear to point to the oösphere as the functional cell. What seem to be disorganized synergids are plainly visible in the embryo-sac after the embryo has begun to form. At any rate the embryo begins its growth by a series of transverse divisions (*figs. 57, 58*). Of the cells thus formed the proximal ones act as a suspensor of very transient duration. The distal cells enlarge to form a pyriform mass in which, at the stage indicated by figure *61*, there is no differentiation in any structure, unless it be a layer of very irregular epidermal cells. The next stage observed in the formation of the embryo is represented by figure *62*, which shows the cotyledons partly developed and the root-cap differentiated. In an embryo of this age there is no tissue differentiation beyond that of root-cap and epidermis. In the radicle, however, the cells have become arranged in regular series converging in the apical meristem.

The development of the parts of the ovule presents no features of importance differing from those already described for some of the foregoing forms. As in other cases, also, the nucellus expands rapidly after fertilization and gives way before the growing epidermis. The seed attains the proportions of maturity before the embryo has proceeded beyond the condition represented by figure *62*.

Momordica

As in the case of *Bryonopsis* and *Trichosanthes*, the ovules of *Momordica* arise as small elevations on the right and left flanks of the placental ridges. The origin of the archesporium was not observed, but the spore-mother-cell was found in an advanced condition (*fig. 63*). In this case it occupies a central position in the rapidly growing nucellus

and is separated from the epidermis by three tabular tapetal cells. The nucellus at this time grows rapidly and the integuments cover only the lower half of it. These arise in the usual manner and by the time the embryo-sac is ready for fertilization they have closed over the top of the nucellus. Until some time after fertilization the outer integuments are relatively thinner than those of the other cases described, except *Fevillea*. The inner integument is always thin.

The division of the spore-mother-cell to form the usual potential megaspores was not observed, though there is evidence that it occurs. In stages somewhat later, certain disintegrating masses were observed above the young embryo-sac, which were taken to be non-functional spores (*fig. 65*). An embryo-sac of two cells was observed, but none between this condition and fertilization. When the oösphere is mature the embryo-sac differs in some respects from the preceding forms. Figures *66* and *66a* represent parts of the same embryo-sacs. The synergids are much less vacuolated and are decidedly hyaline and striated in their upper portions. The oösphere is likewise more compact and the whole egg-apparatus is larger than in most other cases examined. No antipodals could with certainty be determined. If formed at all they must disappear quickly.

The endosperm nucleus is formed by the fusion of two polar nuclei. The nucleus thus formed is conspicuous for its size and chromatic content. Each polar nucleus has a very large nucleolus and these evidently become merged, as only one could be found in the endosperm nucleus. After fertilization the endosperm rapidly increases and the cells of the nucellus are gradually displaced. No starch was observed in the endosperm of *Momordica* at any time. As the endosperm grows, most of its substances become peripherally distributed with numerous small nuclei scattered through it. This condition is maintained for some time, while the expanding surface of the endosperm is gradually replacing the surrounding tissue. Sometimes a thin line of cytoplasm may be seen penetrating the tissue toward the chalaza (*fig. 68*).

About this time the ovule enters upon a very rapid period of growth, and the nucellus, no longer compact, is cleft by the endosperm, which extends toward the chalaza. The endosperm gradually assumes a cellular character, beginning in the region of the embryo. Only in the micropylar region is there any approach to compactness, most of the mass consisting of large thin-walled cells with small protoplasmic content.

The first cleavages of the embryo are transverse and a row of cells is thus formed (*fig. 67*). The subsequent divisions, however are for some time irregular and result in the formation of a globular mass of cells (*figs. 68–70*), in which no differentiation beyond that of the epidermis is visible. A later stage was observed in figure *71* in which the cotyledons were being formed. In this case the differentiation into root-cap, periblem and plerome was well under way. At this stage the dimensions of the mature seed are approximately reached.

Luffa

When the undulations, which mark the origin of the ovules, become evident upon the surface of the placenta (see text-figure *5*, *H*) the groups of cells lying beneath the apex of each incipient ovule present a highly meristematic character. One of these cells soon appears larger than its neighbors and possessed of a very conspicuous nucleus. Sometimes there may be two such in an axial row, the outer one adjacent to the epidermis. The first indication of an archesporium is not always clear. Sometimes the spore-mother-cell itself appears in the hypodermal mass (*fig. 72*). In such a case it is quite conspicuous but no very definite tapetum is apparent. Subsequent divisions of the overlying cells, however, are mostly in periclinal planes (*fig. 73*). Thus a tier of several cells is formed above the sporogenous cell. The latter increases in size (*fig. 74*) until it becomes about two-fifths the length of the nucellus.

The development of the ovule is rapid from the time when the first indication of the archesporium is apparent. When the spore-mother-cell is well differentiated (*fig. 72*) the ovule

has developed a long funicle and the formation of integuments and nucellus is well under way (see text-figure *5*, *I*). The growth of the integuments now exceeds that of the nucellus and they soon enclose it. During this process the divisions of the spore-mother-cell take place.

The manner of division of the spore-mother-cell recalls that of *Trichosanthes*. Of the cells resulting from the first division the outer one degenerates, while the inner one proceeds to divide again (*fig. 75*). The figure just cited shows the conclusion of the second division and the deterioration of the upper of the two cells thus formed. The functional megaspore immediately begins to enlarge preparatory to its first division, which is represented completed in figure *76*. The succeeding divisions are quite regular and the embryo-sac is formed in the usual manner by three successive divisions of the megaspore (*figs. 76–78*). In this form the migration of the polar nuclei begins before any differentiation of other structures is evident within the embryo-sac (*fig. 78*). At this time the embryo-sac is centrally situated in the nucellus, over which the integuments are slightly elevated. Conditions of the embryo-sac like those shown in figures *76*, *77*, and *79* may be found almost in the same section. In such cases, which are usual, the degree of the differentiation of the parts of the ovule is about the same in each, though they vary in size, the more advanced embryo-sac occupying the larger ovule. The difference in the degree of development of the embryo-sac and in the size of the ovule is probably associated with some condition of nutrition, inasmuch as such differences are directly correlated with the position on the placenta. When the egg apparatus has become fully differentiated the embryo-sac occupies the center of the upper half of the nucellus, surrounded on all sides by several layers of sterile cells. The pyriform nucellus is surmounted by a slender beak which passes up through the micropyle. At this time the inner integument consists of two layers of cells, the outer one almost as thick as the nucellus.

In the embryo-sac at the time of fertilization we find a very conspicuous egg-apparatus, which extends over nearly two-thirds the length of the embryo-sac. The oösphere is similar to other cases described, inasmuch as the nucleus occupies its lower portion and a large vacuole fully three-fourths of its volume. The synergids are peculiar in the extent of their vacuolization (*fig. 79*), the nucleus and cytoplasm in each occupying but a small space in the upper end. Here we may note also an absence of the hyaline and striated condition in that degree which characterizes some of the forms already cited.

The antipodals are of quite ephemeral character. They were not observed to persist after fertilization, and usually begin to disorganize prior to that event (*fig. 79*).

The formation of the endosperm apparently has its origin in the usual process, by the fusion of two polar nuclei. While the completed fusion of the polar nuclei was not observed in any case, they were observed in contact. In this condition they were surrounded by a mass of cytoplasm filled with starch-grains. After fertilization the endosperm expands rapidly and displaces the adjoining tissue of the nucellus. Before the first cleavage of the embryo has taken place the endosperm has assumed the usual sac-like form, the nuclei scattered through a densely granular cytoplasm. Starch-grains are still abundant (*fig. 80*) and are more frequently of a compound character. The cell-walls of the nucellus in contact with the lower end of the endosperm show evidences of disintegration. The endosperm soon loses its starch and becomes finely vacuolated (*fig. 81*).

But two stages of embryonic development were observed. The oöspore (*fig. 80*) presents a rather unusual appearance, being large with conspicuous vacuoles. The first cleavage is transverse (*fig. 81*). Of these two the basal retains the characteristics of the oöspore, the other is more densely granular.

Cucumis

The earliest stage observed in the formation of the embryo-sac of *Cucumis* was that represented by figure *82*. Numer-

ous preparations of ovules at about this stage of development were obtained and it seems evident that the spore-mother-cell arises in the usual manner. The tapetum which is formed consists in the earlier condition of a few tabular cells which suffer division by periclinal walls, thus forming an axial row of cells. By the time that the divisions of the mother-cell occur the nucellus has assumed an oval form and the sporogenous cell is covered by the several parietal layers of the nucellus. The ovule at this time is borne at the end of a long funicle and has almost completed its turning to the anatropous position. The integuments have exceeded the nucellus in height. The parts of the ovule are of relative proportions similar to those of *Luffa* and some others.

The divisions of the spore-mother-cell now ensue. The first division results in the formation of two equivalent cells which proceed to the second division simultaneously (*fig. 83*). From this point the development of the embryo-sac proceeds by the usual course. The usual structures are apparent as the time of fertilization approaches (*fig. 84*). The synergids are long and narrow, their tips hyaline and striated and their vacuoles small. As in former cases the nuclei lie immediately above the vacuoles and the structure above the nuclei to the hyaline portion is apparently reticulate. The oösphere resembles a synergid in size and form but differs in the character and position of its vacuole and nucleus (*fig. 84*). The antipodals are three in number and distinctly visible at this stage, and show less evidence of disintegration than in some of the forms previously cited. Here they appear perfectly normal though not large. No evidence could be found, however, of their existence beyond the time of fertilization.

At this time the nucellus is flask-shaped, the bulb-like portion surmounted by a long slender beak. The embryo-sac and its associated structures are quite small in this species of *Cucumis;* the embryo-sac in particular requiring large magnification to bring out the details of its structure.

The polar nuclei migrate to a position just below the egg-apparatus, where they come into contact and probably unite.

The mass of cytoplasm which surrounds them is densely granular and no evidence of starch was observed in the embryo-sac at any time. Oil is abundant in the surrounding cells of the nucellus and to some extent also in the embryo-sac. The endosperm elongates in the direction of the chalaza as soon as fertilization has taken place, and for a time remains quite compact in the region of the embryo. The lower part, however, is a very delicate film which terminates in a sort of cup-like collection of cells like that shown in the case of *Apodanthera* (*fig. 39*). There is a rapid breaking down of all tissue in immediate contact with the embryo-sac even before there is any considerable enlargement of the nucellus. The sac-like character of the endosperm is soon assumed (*fig. 88*) and its cytoplasm becomes more and more vacuolated. The formation of cell-walls begins quite early and is complete before the embryo has attained any considerable degree of differentiation (*fig. 91*). In this condition it is compact upon the surface but composed of large cells within. The details of its structure are shown in figure *93*. Here it will be seen that the cells of the outer layer consist of a dense compact cytoplasm, while in the larger inner cells the protoplasmic content is distributed in a thin layer over the inner surface of the cell-wall. The significance of these facts will be discussed later. It will also be observed (*fig. 91*) that the end of the mass of endosperm in contact with the embryo is not of the same character as the rest of the superficial layer, but is composed of the large cells just described.

The first cleavages of the oöspore are transverse. Several of these divisions in succession result in the formation of a rudimentary suspensor (*figs. 85, 86*). After the first two or three cleavages the subsequent divisions are anticlinal (*fig. 87*) and in somewhat irregular planes. The result is the formation of a pyriform mass (*fig. 90*), which increases in size until it is composed of several hundred cells, when the initial differentiation of root-cap and apical meristem is apparent. The formation of the root-cap is begun by a series

of periclinal divisions at the micropylar end of the pyriform mass (*fig. 92*).

Lagenaria

Text-figure *5*, *K* represents the form of the placenta at the time when the first indication of an archesporium is apparent. Periclinal divisions beneath the epidermis at the apex of each lobe (*fig. 94*) result in the separation of the primary tapetal and sporogenous cells. These periclinal divisions occur in several hypodermal cells and thus several series are found radiating from the spore-mother-cell (*fig. 95*). The division of the tapetal cells and those in the parietal series follows until columns of ten to twelve cells are formed and the sporogenous cell becomes deeply situated in the tissue of the nucellus. In the meantime the integuments have about reached the top of the nucellus. Before the germination of the megaspore takes place they converge above the nucellus and the ovule assumes the form which it maintains until after fertilization.

Division of the spore-mother-cell occurs in the usual manner. The first division results in the formation of two equivalent cells, and each of these again divides (*figs. 96, 97*). In this case, as in some of the foregoing, it is the lowermost of the four cells thus formed which becomes functional. It enlarges rapidly after these divisions and soon enters upon the series of divisions which provide the eight nuclei of the embryo-sac. The division of the four nuclei to form eight occurs simultaneously, as shown by figure *98*. Here the cytoplasm forms a peripheral layer and leaves the center open.

Differentiation of the eight nuclei is soon apparent (*fig. 99*), and the synergids begin to appear with their usual structure. The antipodals are quite distinct and remain so up to the time of fertilization (*fig. 100*). In the latter stage, however, they are visibly shrunken and soon afterwards disappear. The egg-apparatus differs in no essential from those already described.

An abundance of starch is now found in the neighborhood of the polar nuclei, which by this time have come into contact. In the preceding stage (*fig. 99*) no starch was apparent,

hence it is evident that its formation must take place quickly as the time of fertilization approaches. The process of fertilization brings about the usual changes in the appearance of the endosperm (*fig. 101*) which loses its starch and forms a hollow sac. In this case as in others the nucellus breaks down rapidly in the vicinity of the embryo-sac and especially in the direction of the chalaza. The coenocytic character of the endosperm is not maintained in *Lagenaria* so late as in the other forms. The nuclei soon become separated by cell-walls (*figs. 103, 104*), and the endosperm becomes a solid mass. Where the surrounding cells of the nucellus are in immediate contact with the endosperm they break down, and even in the direction of the chalaza where they are not in contact with it. But a certain zone of tissue for some distance from the endosperm takes a darker stain and shows a denser cytoplasmic substance. The growth of the mass of endosperm is principally in length from this time on. The relation which it bears to the nucellus can be seen in figure *105*, which represents the upper one-fourth of that organ. The cleft extends to the base of the nucellus. The condition of the endosperm at this time is represented by figure *106*. The cellular structure on the outside is more compact and increases in thickness as growth advances, though the central portion of the mass remains more open in structure. The hardening of the endosperm begins in the upper portion and extends over the upper half of its surface at the stage indicated by figure *105*. The first divisions in the embryo are transverse (*figs. 101, 102*). In some cases the early cleavages are somewhat irregular (*fig. 102*) and the tendency is early towards an oval or pear-shape (*fig. 103*), with no regularity of cleavage-planes. As growth proceeds the embryo assumes a more oblong shape (*fig. 106*), and it is only at a much later stage that the beginnings of internal differentiation can be seen (*fig. 107*). Then the periclinal divisions in the proximal end indicate the initial stages in the formation of the root-cap. At this stage (*fig. 107*) the endosperm reaches about one-third the distance to the chalaza and the upper part of the nucellus

is entirely disorganized. The lower part appears quite normal except for the breaking down of its cells along the median line. The ovule has now reached the dimensions of the ripe seed and the differentiation of its outer integument is well under way.

Benincasa

The formation of the archesporium proceeds in the usual way in *Benincasa*. The ovules appear to be rounded elevations upon the placental folds and when these lobes have become quite prominent the archesporium appears among the hypodermal cells at the apex of each lobe (*fig. 108*). The tapetal cells undergo few divisions before the sporogenous cell has become quite conspicuous (*fig. 109*). Divisions of the tapetal cells now follow until the spore-mother-cell becomes deeply seated in the nucellus. The integuments make their first appearance about the time the sporogenous cell is formed and bear about the same relation to the other structures as in the previous cases. By the time the first division of the megaspore nucleus has been completed the conical nucellus is covered by the integuments. At this time the incipient embryo-sac may be found at the base of an axial row of from fifteen to twenty cells.

The division of the spore-mother-cell was not observed. There is some evidence that such a division occurs in the appearance of what may be taken for the remains of nonfunctional spores. A black mass of what appears to be disorganized cells is plainly seen at the outer end of the young embryo-sac, but it soon disappears. It would seem also that it is again the lowermost of the series which becomes functional.

In the same section of an ovary, if not upon the same placenta, there may be found embryo-sacs in various stages of development. Embryo-sacs of two, four and eight cells may be found. The appearance of some of these may be seen in figures *110* and *111*. In many cases the most conspicuous element of the nucleus is its nucleolus which seems to embody all the chromatic substance present. Only in the

case of the mother-cell are nuclear structures at all distinct (*fig. 109*). Figures *109*, *110* and *111* are all drawn to the same scale.

The embryo-sac as the time of fertilization approaches assumes a familiar aspect (*fig. 112*). Some of the more important features of the embryo-sac of *Benincasa* are the prominence of the egg-apparatus and the antipodals and the absence of starch, at least up to the stage of development indicated by figure *112*. The cytoplasm surrounding the polar nuclei appears to be rather scant and filled with numerous vacuoles. The complete fusion of the polar nuclei was not observed.

The antipodals, though quite prominent, are here also of only transient duration. They were not found in any preparations of material beyond the fertilization stage, and seem in this case to have no special function. As indicated in figure *112* they seem to be on the eve of disintegration.

The endosperm is quite similar to some that we have already found in previous cases (*fig. 114*). In this case also it is distributed in a sac-like form, which in the upper portions is of the usual thickness (*fig. 114*) but in the lower part is a very thin film. In this condition, before the first division of the fertilized egg, it has made considerable inroads upon the tissue of the nucellus. About ten nuclei have been formed and these are scattered about irregularly. The division of these nuclei, as usual, takes place simultaneously (*fig. 113*). The endosperm of *Benincasa*, like that of *Lagenaria*, soon forms a solid mass of cellular tissue (*fig. 116*). In this case also the peripheral portion becomes denser, and in the upper portion this takes place earlier than in the lower. The same figure shows the appearance of the cells of the nucellus when in contact with the endosperm. The first extension of the endosperm is toward the chalaza and while the growth is rapid in this manner it remains non-cellular. Upon formation of cell-walls, growth is retarded.

The oöspore remains for a short time undivided (*figs. 113*, *114*). A globular or pyriform mass of cells is soon formed

(*fig. 115*). Preparations showing early cleavages were not obtained, but figure *115* appears to indicate that they may have been transverse. In this case at least the subsequent divisions are in various directions. The same embryo in its relation to the endosperm may be seen in figure *116*.

Citrullus

Several longitudinal series of elevations occur on the placentae and these at an early stage appear merely as undulations on the folds as seen in transverse section. When these elevations have reached a height equal to their diameter at the base or slightly more, the first suggestion of an archesporium is apparent. Up to this time all the cells of the protuberance are of about the same character, staining deeply. The archesporium is of very indefinite character. No enlarged cell adjacent to the epidermis (such as occurred in *Fevillea*) was observed. The sporogenous cell (*fig. 117*) appears in an axial row and is recognizable at first only by its size and the open character of its nucleus. When first distinguishable it is covered by two tabular tapetal cells, sometimes very thin and again of an appearance quite similar to the sporogenous cell itself. There is always one axial row apparent, sometimes one or more parietal rows identical in appearance with the axial one. While in its earliest stages the sporogenous cell may not be easily distinguished from its neighbors, the same does not hold true in its later stages. After a short period has elapsed the spore-mother-cell becomes quite distinct both in size and structural features and there is never more than one cell apparent in that condition in the same ovule.

In the same ovary the early phases of the archesporium may be found about alike in all the ovules, but the rate of subsequent development is dependent to some extent upon the position upon the placenta (see text-figure *5*, *M*), those arising on each placenta nearest its median line having the advantage.

The differentiation of the parts of the ovule does not begin until after the sporogenous cell appears. By the time that

the divisions of the spore-mother-cell have been completed the integuments have almost enveloped the nucellus. The proportions of the parts of the ovule are indicated by text-figure *5*, *M*.

After having undergone a period of rest the mother-cell divides to form four potential megaspores. During this period of growth the development of sterile tissue has left the sporogenous cell deep in the nucellus. After the first division of the spore-mother-cell the two daughter-cells again divide, but not simultaneously. The lower one divides first and the division is completed before the division of the upper one (*fig. 118*). The lowermost spore of the four thus formed gives rise to the embryo-sac; the rest disappear.

The development of the embryo-sac takes place by the usual process (*figs. 119–121*). The embryo-sac of eight cells expands in its upper part and the differentiation of the egg-apparatus is begun by the formation of walls about the nuclei and the increase of cytoplasmic substance. This process goes on more slowly at the antipodal end of the sac. The polar nuclei soon come into contact about midway and remain thus for some time (*figs. 121–122 a*). In this case the embryo-sac at the time of fertilization presents about the same appearance as other forms which we have noticed. The egg-apparatus and the antipodals are essentially similar to some of those already studied, though the cytoplasm surrounding the polar nuclei is thin and devoid of starch. The polar nuclei increase in size gradually and probably fuse, though a single endosperm nucleus was not observed at any time.

After fertilization the endosperm nuclei multiply to the number of ten or twelve before the oöspore divides. The cytoplasm becomes distributed in the form of a hollow sac (*fig. 123*) at first, but later assumes a cellular character and becomes solid. As the endosperm begins to expand, the nucellus where in contact with it disintegrates, and the effect of the decomposing influence is apparent for some distance around the embryo-sac, by the modified character of the cell-

walls. These stain more readily by haematoxylon and other reagents to which ordinarily they do not respond.

The endosperm becomes cellular at a very early stage, the formation of walls taking place first in its upper portion. Until an advanced stage is reached in the development of the embryo the lower end of the endosperm remains coenocytic, and is terminated by a long coecum which fits into a pocket of cells in the middle of the nucellus (*fig. 126*). The proportion of parts is shown better in an outline figure (*124*). The cells which constitute this "pocket" are much smaller than the others of the nucellus at this stage and by their protoplasmic contents (nucleus, cytoplasm, etc.) seems to be in about the same metabolic condition as those in other parts of the nucellus. These cells appear identical with those which surround the antipodal end of the embryo-sac at the time of fertilization. All the cells of the nucellus are then small and the subsequent enlargement of the others makes these appear smaller by contrast. Why these cells which surround the antipodals should not keep pace in growth with others is not quite clear, nor is it plain why they should not share the fate of others that are broken down by contact with the endosperm. They remain surrounding the extremity of the endosperm until long after the tissue of the nucellus has separated along the median line to the chalaza. The upper and the lower ends of the same mass of endosperm are shown in figures *125* and *126* respectively. The character of the cellular endosperm is entirely similar to that with which we have already become familiar in the preceding forms. The endosperm finally becomes entirely cellular, but while the outer layer consists always of a layer of small cells with dense cytoplasm, the cells of the central part expand to a size many times that indicated in figure *125*, and show the merest trace of cytoplasmic contents. In this condition there is little evidence of its being at all active in the nutrition of the embryo.

The development of the embryo proceeds apparently in about the same way which we have seen in the other forms.

Starting with a single cell which elongates (*fig. 123*), a spherical mass is soon formed which later becomes broadly pyriform (*fig. 125*) with no internal differentiation apparent. If a suspensor is formed at all it is of only transient character. In none of those embryos which had reached a multicellular state was there any evidence of a suspensor.

Cucurbita

The development of the ovules upon the placenta has already been referred to and the different phases of the process are indicated by text-figures *6, A* to *6, D* inclusive. As in the case of *Citrullus*, the origin of the archesporium is obscure. The cells at the apex of the incipient nucellus are all of similar appearance, being of a highly meristematic character, until one larger than the others appears in an axial row separated from the epidermis by two or more cells, presumably the tapetum (*fig. 127*). This cell increases in size while the cells surrounding it segment irregularly. The sporogenous cell assumes a large size in this form and like the others becomes centrally situated in the nucellus (*fig. 128*).

The divisions of the spore-mother-cell appear to be regular. The first division results in the formation of two equivalent cells (*fig. 129*), which again divide to form four potential megaspores. Of these the lowermost produces the embryo-sac (*fig. 129 a*), the others soon showing signs of disorganization. At this stage of development the nucellus consists of a bulbous lower portion surmounted by a narrow prolongation of its tissue which extends upward through the micropyle. By this time the differentiation of the outer portion has reached that stage in which the integuments have enveloped the nucellus and contracted above to form the micropyle.

The divisions of the spore nucleus which now follow produce the embryo-sac in the usual manner. The course of development presents no features worthy of particular mention. After the eight-cell stage is reached the process of differentiation goes on as indicated in *Citrullus*. Figure *131* represents a partially formed embryo-sac in which the syner-

gids and oösphere can be clearly distinguished. Here the polar nuclei are smaller than they appear later and the antipodals are in their prime. The antipodals will be seen to mature much earlier than the other cells of the embryo-sac and have practically disappeared before the others have come to maturity (*fig. 132*).

The embryo-sac of *Cucurbita Pepo* presents a very striking appearance. The endosperm nucleus is possessed of an especially prominent nucleolus and is surrounded by a cytoplasm gorged with starch. The synergids being about two-thirds the length of the embryo-sac are somewhat compressed by the cytoplasm which surrounds their lower portion, which in each case consists of a very thin film enclosing a large vacuole. The nucleus in each case lies just above the vacuole and the upper two-fifths of the cell is hyaline and marked by exceedingly fine striations. In the embryo-sac of another garden variety of *Cucurbita*, the common crook-neck squash (*fig. 137*), the conditions are not the same, though in some points the comparison is hardly fair inasmuch as they are not quite in the same stage of development. The egg-apparatus presents much the same appearance as in the other form of *Cucurbita*, but antipodals are entirely absent. One feature is the entire absence of endosperm, though this may be due to the earlier state of development. The enormous size of the nucleoli in the polar nuclei is here one of the most salient features.

Endosperm develops in *Cucurbita Pepo* much as in other forms, in this family. Figures *134*, *135* and *136* represent its appearance in various stages. The starch disappears early and the mass of cytoplasm becomes distributed peripherally, and twenty-five or thirty nuclei may be formed before the oöspore has completed its first segmentation. The cytoplasm is more dense in the upper than in the lower portion and here also the nuclei are more numerous. The tissue of the nucellus falls before the growing endosperm. The endosperm soon becomes cellular in structure, the formation of walls beginning in the micropylar region (*fig. 136*).

The development of the embryo in *Cucurbita* has not been followed out. Only a few early stages were observed. The development of the embryo appears, however, to proceed slowly, and considerable endosperm may be formed before the first division of the oöspore takes place. The condition represented by figure *138* was found in another garden variety, the Chile squash. In this it is apparent that the first walls to be formed are transverse, but the succeeding ones may be anticlines and probably give rise to a mass of cells similar to those found in the other forms.

Sicyos

About the time that the young ovule begins the turning which finally brings it to the anatropous position the young spore-mother-cell appears below the epidermis at the apex of the nucellus. The same difficulties which hinder the identification of the early archesporium in *Cucurbita* and some other forms are present here. But the presence of two or three tabular cells between the sporogenous cell and the epidermis seems to indicate that the structures in question originate in the usual manner. The tapetal cells undergo repeated divisions tangentially, and by the time the spore-mother-cell is ready for division it has become covered by a long axial row of cells. In fact, the divisions have followed so slowly on the side toward the chalaza, that the sporogenous cell at this stage is much nearer to the chalaza than to the apex of the nucellus. The relative development of the integuments at this period is similar to that observed in other forms.

The spore-mother-cell apparently undergoes the usual divisions in the formation of the megaspore. While these divisions were not observed, nor were the four potential megaspores, the presence of a disintegrating mass of material in the vicinity of the megaspore (*fig. 141*) would be in favor of such an assumption. Furthermore it would appear that the functional megaspore is the lowest one, as in the previous cases.

The two-celled embryo-sac was not observed. But figures *142* and *143* show the four-celled and eight-celled stages

respectively. In the latter the prospective function of the different cells can be determined by their position and appearances, although it is far from the mature condition, as may be seen by a comparison of figures *143* and *144*.

In the mature embryo-sac the synergids and oösphere are less vacuolated than in many of the other forms cited and the polar nuclei are not nearly so prominent. No starch was observed in the embryo-sac at any time, though oil was often visible (*fig. 144*). In this embryo-sac, which represents the conditions prevailing near the time of fertilization, antipodals are plainly evident, though apparently not functional. They were not found in any preparations of more advanced material, and so must be, like the others, of ephemeral character.

The formation of the endosperm proceeds as usual. A mass of sac-like form soon appears and elongates rapidly toward the chalaza (*fig. 145*). In this numerous free nuclei are visible at an early stage and they multiply as the mass expands. The character of the cytoplasm is at first open and vacuolated, but later it appears densely granular and homogeneous (*fig. 146*). At this point a large regular central vacuole is formed and the lower portion becomes drawn out into a thin strand which penetrates deeply toward the chalaza. Walls are formed in the upper portion, and half of the endosperm may sometimes appear cellular and half non-cellular (*fig. 147*).

The embryo develops slowly and various stages in its formation were observed. The earliest condition seen presented the appearance shown in figure *145*. Here the first division seems to have been diagonal and the second intercepting this plane and dividing the distal one of the two cells formed by the first division. The subsequent divisions give rise to a pyriform mass (*fig. 146*), and later to the usual structures described for other forms.

Micrampelis

In this form the initial stages in the formation of the archesporium were not observed. By the time, however, that the

integuments have become elevated to the top of the nucellus the spore-mother-cell has become quite conspicuous at its center, and is surmounted by an axial row of cells. Here the form and relations of parts of the ovule are similar to those previously considered (*fig. 148*).

It is evident that the spore-mother-cell divides as usual to form potential spores, though the process was not observed in its completeness. The first division takes place and the cell is divided equally (*fig. 149*). In the two-, four- and eight-celled stages we find a perfectly typical development. In each case the center of the embryo-sac is occupied by a large vacuole (*figs. 150–153*) which becomes more or less modified as development proceeds.

In the mature embryo-sac of *Micrampelis* the various organs are quite prominently displayed. The egg-apparatus consists of a conspicuous oösphere and two very bulky synergids, in which there is rather less vacuolization than is evident in most of the forms. The antipodals are more conspicuous here than in any of the preceding species (*fig. 155*). The cytoplasm which surrounds the endosperm nuclei presents a finely vacuolated appearance, but at no time was any starch observed in it. The polar nuclei were not observed to fuse, but they were found in contact at the time just preceding the fertilization. As the embryo begins to form, the endosperm rapidly expands and the cytoplasm assumes a much more dense and compact character in its upper portion, and numerous nuclei are scattered through it (*fig. 156*). As development proceeds, however, its structure becomes more open and it has begun to encroach upon the nucellar tissue (*fig. 157*). Up to this time no walls have been formed between the nuclei, but this condition does not last long. The endosperm early becomes a solid cellular mass (*fig. 158*), in form wedge-shaped and often easily dissected out of the ovule. In this condition the mass makes rapid inroads upon the nucellus, the cells of which show the effect of some disintegrating agent wherever in contact with the endosperm. This disintegration appears in the swelling of the cell-walls and the breaking up of the

protoplasm of the cells. The process of cell-formation is initiated in the region near the embryo and the more distant parts are the last to become transformed. The compact character of the upper and peripheral portions of the endosperm is apparent only in the earlier stages; that which is found later being of a much more open nature (*fig. 159*). The expansion of the ovular tissue proceeds rapidly and by the time the endosperm has reached the cellular state (*fig. 158*) the ovule has almost arrived at mature proportions.

The first divisions of the oöspore are transverse (*fig. 156*) and the suspensor consists usually of two cells, the third a terminal cell constituting the proembryo. The cleavages which follow in the proembryo are more or less irregular (*fig. 157 a*). The subsequent divisions give rise to a pyriform mass of cells crowded into the apex of the nucellus. The external differentiation of the embryo proceeds as in the other cases cited, and the origin of the cotyledons is evident before any interval differentiation is apparent (*fig. 159*).

Coccinia

Owing to the difficulty experienced in growing this form the material obtained was but fragmentary. Hence only a glance can be taken at the condition observed in some of the earlier stages.

In this form, which is included in this tribe chiefly on account of the characters of the androecium, the ovules appear upon the placenta as in the case of some of the Cucurbiteae (see text-figure 6, *E* to *F*). In *Coccinia*, as in some of the previous cases, the character of the tissue in the apex of the young nucellus makes it difficult to identify the archesporium. Only when the development of the megaspore-mother-cell is well advanced, does it appear probable that the origin of the tapetum and the primary sporogenous cell takes place after the usual manner (*fig. 139*). In the cases observed the sporogenous cell appeared situated below an axial row of sterile cells. In this as in previous cases the growth of the ovular organs, integuments, etc., keeps pace with the internal differ-

entiation, and there is no variation from the typical form worthy of mention.

Cyclanthera

In the very young ovules the cells are arranged in confocal series and the archesporial cell is not easily distinguished from the others in size or other features (*fig. 160*). Subsequently the spore-mother-cell appears quite distinct and the tapetal cells to the number of two or more, separate it from the epidermis (*fig. 161*). At this time the initial stage in the formation of the inner integument is visible in the usual form of a slightly elevated ring due in some places to a radial elongation of epidermal cells and in others to periclinal divisions of the hypodermal elements (*fig. 161*). In the subsequent growth of the ovule the sporogenous cell becomes deeply placed in the nucellus. The repeated divisions of the original tapetal cells and the parietal series are evident. The long axial series of cells thus formed is shown in figure *162*.

The spore-mother-cell undergoes the usual divisions and the fertile cell resulting is here also the lowermost of the series (*fig. 163*). The remains of the non-functional megaspores are evident for some time around the distal end of the embryo-sac.

In the development of the embryo-sac from this point on only one early stage was observed. This was the two-cell stage resulting from the division of the megaspore. There is no indication of any irregularity in the process of development. In figure *164* a nearly mature embryo-sac is shown and this differs in no conspicuous way from those previously cited. The egg-apparatus presents the usual appearance with striated and vacuolated synergids. The antipodals are evanescent and apparently devoid of any important function.

The cytoplasm surrounding the polar nuclei presents a rather peculiar appearance (*fig. 164*). The coarser elements of this cytoplasm are distributed in a radiating order around the polar nuclei, which here are seen to be in contact. Bodies with the aspect of vacuoles, whose limiting membrane stains deeply and appears to be relatively thick, are quite conspicu-

ous. That these may be in some sense an accidental feature, due to some process in the preparation of the material, is possible, though this was the only place where they were found, and the same methods were used in the preparation of the material of *Cyclanthera* that were used in other cases. No starch was observed in this or later stages.

After fertilization the endosperm nuclei increase in size and multiply rapidly (*fig. 165*), and the mass as a whole expands in the hollow form.

PART III. DISCUSSION AND CONCLUSIONS

The facts set forth in regard to the organogeny may be summarized briefly as follows: The pistillate flower begins as a lateral outgrowth, the apex of which becomes depressed and then concave. The sepals arise first around the margin of the torus and the petals follow on an inner circle, the members alternating with the outer series. Within the circle of petal-rudiments the carpels arise and become extended upward to form the style. The placenta arises as a longitudinal ridge upon which the ovules are borne laterally, except in the case of *Sicyos*, in which the ovule is pendent from the top of the ovary.

Of those forms whose development has been studied and described above, it appears that *Fevillea* is the most primitive. It is easy to see how all the others may have been derived from such a form. Although, as Müller[64] suggests, the ovary of the Cucurbitaceae may have consisted originally of five carpels, the simplicity of floral construction in *Fevillea*, in both staminate and pistillate flowers, points to the possible course of evolution of the ovary of this family. Without entering at present upon a discussion of the difficult problem of the morphology of the androecium, some facts have been observed in the ontogeny of the ovary which may be discussed in this connection.

In the three tribes, Fevilleae, Melothrieae and Cucurbiteae, the prevailing type of ovary is the tricarpellary form, and

various degrees of specialization may be observed culminating in the fruit of *Cucurbita Pepo*. In the members of these tribes we may note varying degrees of development of

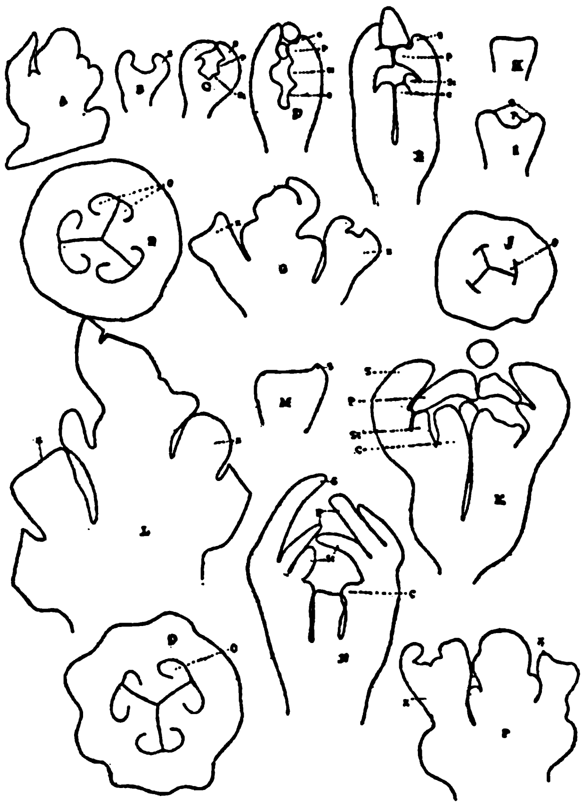

FIG. 1. Development of the gynoecium. *A* to *F*, *Melothria*; *A*, apex of shoot; *B*, *C*, *D*, *E*, stages in the development of the ovary; *F*, transverse section of ovary. *G* to *K*, *Bryonopsis*; *G*, apex of shoot; *H*, *I*, *K*, development of ovary; *J*, section of ovary a little later than *K*. *L* to *O*, *Momordica*; *L*, apex of shoot showing two young pistillate flowers, *x*; *M*, *N*, young pistillate flowers; *O*, section of ovary. *P*, apex of shoot and young pistillate flowers of *Trichosanthes*.

the spongy tissue which fills the locules of the ovary and invests the seeds completely in certain genera (*Cucurbita*, *Citrullus*). While the early stages in the ontogeny of the ovary are very similar so far as observed throughout this

family, those changes which mark the appearance of specific and generic characters are soon apparent. The same character may appear later in the ontogeny of the organs in one

Fig. 2. Development of the gynoecium. *A* to *E*, *Trichosanthes*; *A*, *B*, *C*, *D*, stages in the development of the ovary; *E*, section of ovary. *F* to *I*, *Luffa*; *F*, apex of shoot; *G*, *H*, *I*, development of floral organs. *J*, *K*, *Lagenaria*; *J*, apex with two lateral floral rudiments; *K*, section of young ovary. *L*, *M*, *Cucumis*; *L*, apex with young flowers; *M*, longitudinal section of young ovary. *N* to *S*, *Citrullus*; *N*, apex; *O*, *P*, *R*, *S*, longitudinal sections of young flowers showing origin of organs.

genus than in another, as for example in the filling of the locules of the ovary by placental tissue. This occurs at an early stage in most of the Cucurbitaceae, even before the formation of the spore-mother-cell. In *Fevillea* the ovules

are free in the locules until some time after fertilization, and there is no expression of a tendency toward the development of spongy tissue until much later. The ovary of *Fevillea* is in its earlier stages imperfectly divided into three locules and

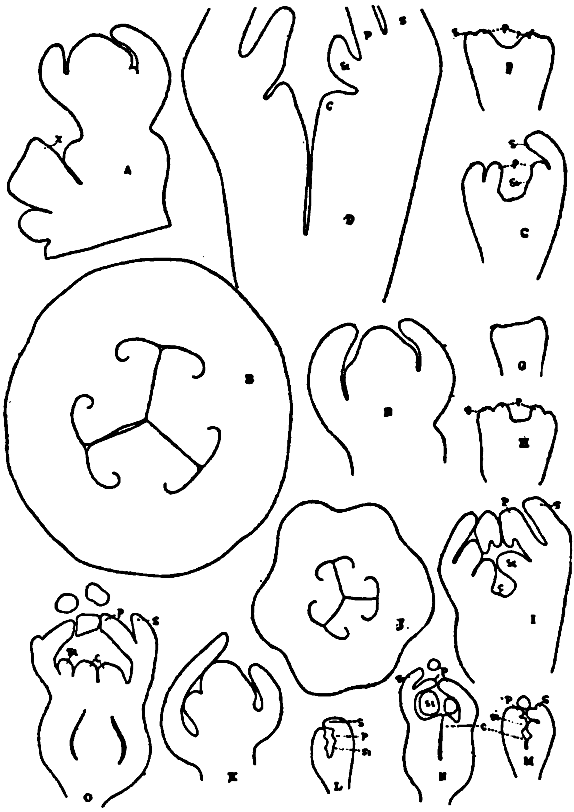

Fig. 3. Development of the gynoecium. *A* **to** *E*, ***Cucurbita Pepo***; *A*, **apical region of shoot;** *B*, *C*, *D*, **floral rudiments in longitudinal section;** *E*, **transverse section of young ovary.** *F* **to** *J*, **similar stages in the development of** ***Coccinia***. *K* **to** *O*, ***Micrampelis***; *K*, **apex of shoot;** *L* **to** *O*, **longitudinal sections through young ovary.**

communication of the interior of the ovary with the exterior is maintained by the imperfect fusion of the ingrowing folds to a much greater degree than is to be found in any such form as *Melothria*, *Cucumis*, *Cucurbita*, *Sicyos* or *Cyclan-*

thera. This weak development of the septa in the ovary of *Fevillea* is still more significant when we consider the condition found in some related genera (*Alsomitra*, *Zanonia*) in which the ovary, composed of three carpels, is unilocular and open to the exterior at the apex. The development of placental tissue which finally fills the locules in *Fevillea* occurs quite late and never to that degree found in members of the Melothrieae and Cucurbiteae.

Among the Sicyoideae, *Coccinia* represents the condition closely approximating that found in the preceding cases so far as the structure of the ovary is concerned (see text-figure *3*). The carpels unite to form the partitions, and the placentae in the same manner as in the Cucurbiteae. In the case of *Micrampelis*, however, only two carpels are apparent, each of which produces, in our species, but two ovules. The margins of the carpels form two longitudinal elevations which meet at the center and become flattened against one another as in the preceding cases, but instead of a row of ovules upon each flank there appears but one, making four in the entire ovary. While no evidence of more than two carpels has been found in any of the young ovaries of *Micrampelis* examined, nor of more than one ovule on the placental fold in any case, yet it seems probable that the ovary of this form is derived by the reduction of three carpels to two. We find in fact that this form as well as others is subject to some variation, and ovaries are frequently found in the mature state evidently composed of three carpels, inasmuch as they contain three locules and six seeds. But the prevailing number of locules is two. We are reminded of the peculiar apron-like character of the placenta of *Micrampelis* in the development of that organ in *Luffa* and others of the Cucurbiteae, in which there is a downward prolongation of the placenta toward the base of the ovary for a considerable distance beyond its insertion. If in the case of *Luffa* but a single ovule were to arise on each flank of this downward prolongation, we should have a condition quite similar to that noticeable in the early stages of *Micrampelis*. Inasmuch as we find at no stage in

the development of the ovary of *Micrampelis* evidence of aborted carpels or ovules, it may be questioned whether in this form we have an ovary derived by reduction from one

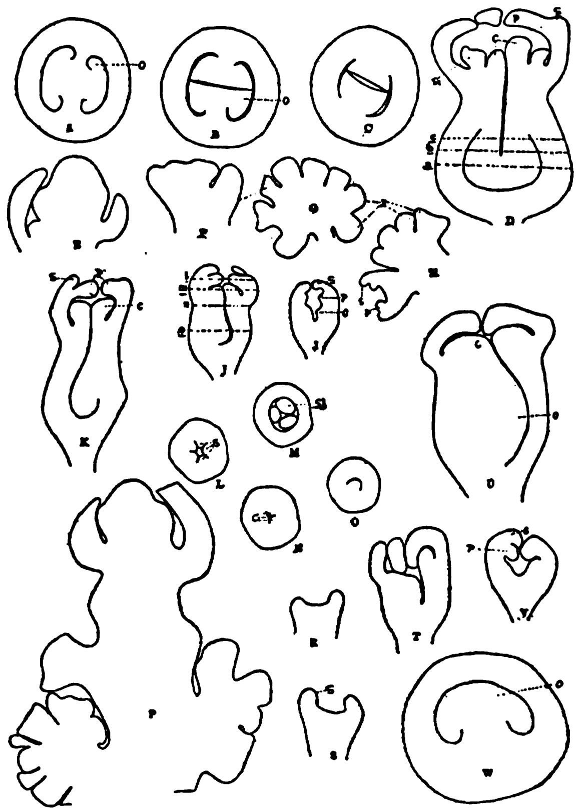

FIG. 4. Development of the gynoecium. *A* to *D*, *Micrampelis*; *A*, *B*, *C*, sections through different regions, *a*, *b*, *c*, of the ovary, *D*. *E* to *O*, *Sicyos*; *E*, apex of shoot; *F*, *G*, *H*, clusters of rudimentary pistillate flowers at different ages; *I* to *K*, longitudinal sections through young ovaries at different stages; *L* to *O*, transverse sections through *J* at the regions indicated by small letters. *P* to *W*, *Cyclanthera*; *P*, apex of shoot; *R* to *V*, longitudinal sections of ovaries at different ages; *W*, transverse section through ovary of about the size indicated by *U*.

having three or a greater number of carpels and a greater number of ovules, but from the fact that the prevailing number of carpels in most of the members of this family is three

it seems more reasonable to regard the ovary consisting of two carpels as derived by reduction than as representing a more primitive type. In the development of *Sicyos* there is distinct evidence of such reduction (see text-figure *4*). The earlier stages of the development of the gynoecium are marked by the appearance of three equidistant elevations on the torus, which by their position and behavior, must be regarded as incipient carpels. We have here a reduction in the number of functional carpels as shown by the formation of a single placenta, a case therefore quite similar to what might appear should one of the three placental lobes of a form like *Bryonopsis* or *Coccinia* bear a single ovule and the other placental lobes become reduced or obliterated. While the ovules of *Bryonopsis* and *Coccinia* are horizontal, it is quite probable that if they were reduced to one as in the case of *Sicyos* its position would be changed to the vertical.

Cyclanthera in a comparison with *Sicyos* would represent a condition intermediate between that of *Sicyos* and a radially symmetrical form such as *Bryonopsis* or *Fevillea*. If in the ovary of *Cyclanthera explodens* the two rows of ovules should be replaced by a single ovule in vertical position, the condition would be entirely similar to that of *Sicyos*. In the incipiency of the gynoecium three lobes may be recognized, though not so distinctly as in *Sicyos*, and these soon become obliterated in the stigma. It seems quite evident that the ovary of *Cyclanthera explodens* has also been derived from a tricarpellary form. By the abortion of two of the three placental ridges in a form like *Bryonopsis* a condition would result in all essential respects similar to that existing in the ovary of *Cyclanthera explodens*.

The growth of the placenta and the origin of the ovules are matters of interest and are worthy of attention. Evidently the simplest form of placentation is that in which numerous seeds arise on parietal placentae in a unilocular ovary (*Alsomitra*). From this condition it is easy to trace the gradual ingrowth of the edges of the carpels and the development of the various features of placentation, already described

to some extent. Text-figures *5* and *6* are designed to represent some of these features.

The condition met with in *Fevillea* shows a step in advance of the parietal placentation in that the carpels have pushed in toward the center of the cavity and have there become flat-

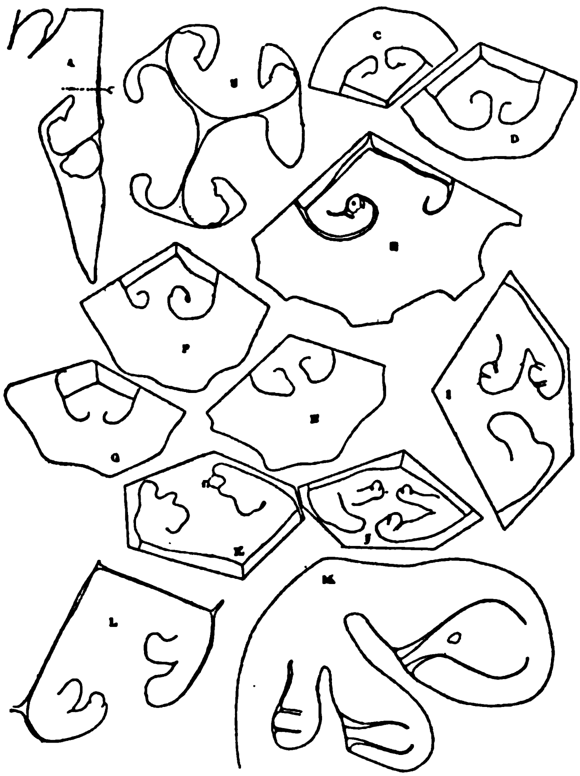

FIG. 5. Placentation. *A*, *B*, *Fevillea*. *C*, *Melothria*. *D*, *Bryonopsis*. *E*, *Momordica*. *F*, *Trichosanthes*. *G* to *I*, *Luffa*. *K*, *L*, *Lagenaria*. *M*, *Citrullus*. *J*, *Cucumis*.

tened by mutual contact. As may be seen, the ovules, borne on rather long funicles, are in the earlier stage horizontal and in this respect the condition evident here is in no essential different from that found in *Melothria*, *Bryonopsis*, *Momordica*, or *Trichosanthes*. In these latter forms the ovules are more numerous on each flank of the placenta. It will be

noted that in *Luffa* and other members of the Cucurbiteae, and in *Coccinia* and *Melothria*, the early condition of the placentae is uniform, but a differentiation soon appears which distinguishes one from another. Certain outgrowths from the

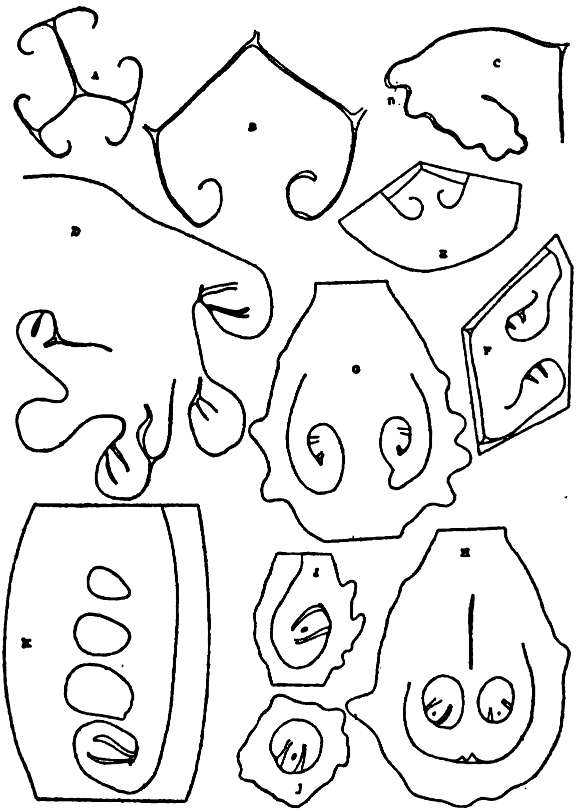

Fig. 6. Placentation. *A* to *D*, *Cucurbita Pepo*, showing origin of ovules and their comparative development on the same placenta, *D*. *E*, *F*, *Coccinia*. *G*, *H*, *Micrampelis*. *I*, *J*, *Sicyos*. *K*, *Cyclanthera*.

placental flanks mark the point at which the ovules arise. This is shown clearly in the case of *Luffa*, and also in *Lagenaria* and *Cucurbita*. In *Luffa* and *Cucumis* two ovules arise on each flank, but in *Lagenaria*, *Citrullus*, and *Cucurbita* the number varies from two to several.

As to the nature of the inferior ovary in the Cucurbitaceae, Naudin[66] (1855) expressed the view that it was always wholly or in part invaginated in the tissue of the peduncle, and that the calyx is generally free from adherence to it. In support of this position he cites cases where the calyx-lobes return to foliar conditions with distinct laminae and petioles.

This view of the nature of the inferior ovary was not new with Naudin. Schleiden[76] (1846) after investigations on *Rosa*, *Leucojum*, *Godetia*, *Epipactis* and some other plants, concluded that the ovaries were formed entirely of the floral axis; furthermore that the carpels were only the upper part of the ovary and that their tips run up to form the style and stigma. According to his view the conception of the inferior ovary as a fusion of the carpels with calyx and corolla was an assumption unnecessary if not untenable. He points out that in the development of the flower in *Canna exigua* and other plants the invagination at the apex of the axis, which is the beginning of the formation of the ovary, takes place before there is any trace of the appearance of the perianth, and further that in many cases the calyx and corolla are entirely separate and stand free from the ovary. And so the ovary, pistil and stigma represent modifications of no particular organs but are sometimes of axial, sometimes of foliar character.

Goebel,[80] however, in 1886, studied the development of *Pyrus Malus* and shows that the carpellary leaves are laid down in the young flower, but that the subsequent intercalary growth of the zone on which they are inserted produces an ovary "lined inside by the insertions of the carpels." This zone in a perigynous flower is but slightly widened. The ovary of *Pyrus* Schleiden did not regard as truly inferior but as representing a fusion of carpels and floral axis. Goebel, however, regards it as the product of the growth of the bases of the carpels and the zone upon which they are inserted. All investigations upon the development of inferior ovaries, he concludes, must reckon with the question as to how much of the area of the base of the flower is occupied by the incipi-

ent carpels. In the younger stages, which show the first laying down of the carpels, particularly in the Umbelliferae and the Compositae, the carpels cover the whole of the inside of the depression, and sometimes the gynoecium takes up the whole of the vegetative point. In his words then it may be summed up: "die Placentation im überständigen und unterständigen Fruchtknoten eine ganz obereinstimmende, eine Thatsache, die auf eine übereinstimmende Betheiligung der Fruchtblätter in beiden Fällen hinweist."

B. Schaefer[73] (1890) traced the development of the ovary in numerous plants, among which were the Campanulaceae. The particular representative taken from that family was *Phyteuma nigrum*, in which he finds that the carpellary "Anlagen" are laid down while the terminal concavity is yet quite shallow and appear as two opposite elevations on a slightly elevated ring extending to the base of the cavity. Transverse divisions of the first two or three periblem layers of cells at the sides of the base of the concavity elevate the overlying tissues and so deepen the depression. He says that the tissue which forms the covering of the ovarian cavity appears as an outgrowth of the parietal placental folds. In conclusion he says that the placentation in inferior ovaries, which he investigated in the Compositae, Onagraceae and Campanulaceae, is wholly in accord with that found in superior ovaries. He carefully points out the course of development in the different forms and maintains that the carpels form a lining of the ovarian cavity, their backs being fused with axial tissue. After quoting from Goebel's work, above cited, he says: "So befand sich die Entwickelungsgeschichte in schroffem Gegensatz zur Morphologie, welche auf Grund theils von vergleichenden untersuchungen, theils von Missbildungen zu der Annahme gekommen war, dass die Fruchtblätter sich auch an der Bildung des Unterständigen Fruchtknotens betheiligen, indem sie, mit ihren Rückentheilen an die Axe gebunden, die Innenseite der Höhlung auskleiden."

The facts observed in connection with the development of the ovary in the Cucurbitaceae, apparently support the conten-

tion of Schleiden that the placentation is mainly of an axial character and that the carpels contribute principally the upper portion of the ovary and the style. Here also we are in accord with the conclusions of Lestiboudois,[52] who studied the process of development in *Cucumis* and *Bryonia*. He states that the carpels appear as projections which elongate and finally close the cavity before the formation of the ovules.

Furthermore, that the carpellary "mamelons" are the same in appearance as those which represent the sepals, petals and stamens (staminodia). This appears most distinctly in the case of *Fevillea* (*pl. 58, fig. 6*), but in all the other cases it is to some extent apparent and in some more than in others. After the first appearance of the carpels as minute lobes on the peripheral surface of the torus, there is in every case an accelerated growth of the periblem layers situated just below the insertion of the carpels, that is, toward the center of the torus. The growth of the ovary takes place then mainly below the insertions of the carpels, the cells around the bottom of the cavity retaining for some time a distinctly meristematic character. The bottom of the original concavity which is indicated by the termination of the stylar canal is in some cases (*Luffa*) far removed from the lower end of the placenta in its later stages, the growth having occurred mainly in the lower portion of the ovary. There is no evidence of the fusion of the backs of carpels, either with axial tissue or with portions of the perianth, and such an assumption here seems unnecessary.

Text-figures *1–4* inclusive show the course of ontogenetic development in the gynoecium as already described at length in the treatment of the organogeny. The zone of growth just below the insertion of the carpels is, in every case, clearly apparent. In certain cases, as in *Fevillea*, the placenta is evidently foliar in origin (text-figure *5*, *A*), and possibly in *Sicyos* (text-figure *6*, *I*), but in all the others examined it arises not from carpellary tissue but by a thickening, in certain definite regions, of the ovary wall.

The influence of the carpels is sometimes manifest in an

earlier development of the ovules in their region than on parts of the placenta more remote, as might be expected where the function of seed-bearing has been transferred gradually from sporophylls to axial tissue, though this condition may be due to better nutrition. Too much emphasis can hardly be laid upon the peculiar character of the placenta in this family. We have noted the different forms which the placenta assumes and the varied structure of the ovary, and all the facts observed point to the placenta as a center of variation. It is here that we find evidence of the gradual assumption of the function of reproduction by tissues of an axial nature and a corresponding decrease in the extent to which foliar tissue is concerned in this work. This indicates a certain degree of plasticity in the axial tissue, which is further expressed in the multiplying of ovular series on the placental folds, to which attention has been called in the comparison of forms like *Melothria*, *Cucumis* and *Cucurbita*. It is apparent here that we have a condition of morphological independence in which new powers of variation are acquired, which have been utilized in the various modifications of placenta and ovary already pointed out. While it is true that the number of placental folds generally corresponds to the number of carpellary rudiments, this is not always so (*Sicyos*); and in those cases in which the number of placental ridges is usually three, four or five may sometimes be found (*Cucurbita Pepo*); and where two is the rule three may occur, etc. In other words a condition of variability exists which is more or less restricted by hereditary tendencies (Ganong[26]).

The more important features of the ovule and embryo-sac of the various species examined have been described. A comparison of these facts shows a considerable degree of uniformity in the development of these structures between the most widely varying members of the family. The ovule in all cases is anatropous and the relative importance, in point of size, of the nucellus and the integuments is quite constant in all the species investigated. The ovules of the Cucurbitaceae differ from those of most other Sympetalae in some

respects, as already pointed out in the discussion of *Fevillea*. The nucellus in this family is much more prominent than in other members of the sympetalous group, and differs from these further in the fact that two integuments are always present though the inner one seldom attains a thickness of more than two cell-layers. The outer integument is always conspicuous and the walls of certain layers of its cells become peculiarly thickened and sculptured. It will be noted that in *Fevillea* we have the least departure from the typical sympetalous condition in the relative size of outer integument and nucellus, although here the inner integument finds its greatest degree of development, which may partly be due to its formation in an open ovary, where it is free from the pressure of the surrounding tissue. If the facts in the development of the gynoecium will justify our conclusion that *Fevillea* is a more or less primitive form in this family, it would appear that the peculiar characters of the ovule in the Cucurbitaceae are not primitive but specialized.

In the formation of the archesporium, evidence points to a single archesporial cell as the forerunner of the sporogenous tissue. While in some cases the definite hypodermal archesporial cell was difficult to identify, the character of the hypodermal mass concerned did not seem to justify the distinction of a multicellular archesporium. It appears, therefore, that the members of the Cucurbitaceae conform to the usual type in this respect, though in some cases expressing apparently no very distant departure from the presumably primitive condition of an archesporial complex.

In one point in the subsequent development the species herein described present features much at variance with the corresponding stages in other Sympetalae. Here we find no tendency toward a reduction of the tapetal or parietal (Coulter and Chamberlain[15]) cells. These are always multiplied to the number of ten or twelve before the embryo-sac is formed. If the suppression of the tapetum is to be regarded as a specialized condition, for which there seems some reason, we find here another primitive character, though we should not

lose sight of the fact that such conditions exist in many of the lower angiosperms.

In the division of the primary sporogenous cell four megaspores are usually formed, and the condition in this family is therefore in harmony with the almost universal habit in the Sympetalae. In all the cases where it was observed the tetrad was a straight row of cells of which it was always the one at the chalazal end of the series which became functional, the only apparent reason for the selection of this cell being its more advantageous situation with reference to the source of nutritive materials which come through the chalaza, an idea which Koernicke has also expressed.[50] In all cases the spore enlarges considerably and then proceeds to the regular series of divisions, which usually gives rise to but eight nuclei from which the egg-apparatus and other structures are differentiated. Very few mitoses were observed in all the preparations examined and no generalizations can be made concerning conditions upon which such facts are supposed to throw light. Where the divisions were observed they were simultaneous within the same sac, and there was no evidence of the most evanescent kind of a cell-plate. In the formation of the egg-apparatus and the development of its particular features we recognize those characters so common among the dicotyledons and the Sympetalae in particular. In fact in all essential features the embryo-sac is similar to many others, from various sources and cycles of affinity. The polar nuclei in many cases have been observed to unite before any evidence of fertilization was apparent. While neither of the polar nuclei was observed to lie in contact with the egg-cell their position was uniformly close to it. The lower of the polar nuclei always migrates to the vicinity of the egg-apparatus, where it unites with the upper one; but no migration of the fusion nucleus occurs as observed by Ikeda[44] in *Tricyrtis hirta*.

Among the Sympetalae there is a tendency toward the retention of the antipodals, and even in some cases toward the formation of tissue by their proliferation. But such is not

the case here, where it has been shown that the antipodals are never of more than transient duration. There is absolutely no evidence that these cells in the Cucurbitaceae are at all concerned in any of the formative or nutritive work carried on in the embryo-sac. In the development of some of the forms here considered the failure of the antipodals to develop is accompanied by a cessation of growth in that region not only in the embryo-sac but also in the cells of the nucellus which immediately surround them; so that in much later stages when the cells of the nucellus have expanded to many times their former size, the mass of cells referred to forms a sort of pocket into which is inserted the end of the vermiform prolongation of the endosperm (*Citrullus*, *Apodanthera*). Not only is this true, but a slight thickening of the walls of these cells takes place and an appearance, as if cutinized, is one of the more conspicuous features. Other cases of the retardation of the antipodal region have already been observed in *Typha*, *Sagittaria*, *Oenothera* and other genera.

The process of fertilization and the origin of the embryo is still an open question in the Cucurbitaceae, except for the case of mesogamy cited by Longo in *Cucurbita Pepo*. * In the many preparations that were made and studied not one showed this phase with sufficient clearness to justify any conclusions. There is evidence, however, that the processes of fertilization and embryo-sac development are normal. † In the case of every species studied, except *Coccinia*, the presence of the pollen-tube was detected in the micropyle and in many cases it had even penetrated through the tissue of nucellus into the embryo-sac. In the case of *Cucurbita Pepo* the end of the pollen-tube was found in the micropyle before it had reached the embryo-sac. In its extreme end appeared the large vegetative nucleus and just posterior to this two smaller ones, presumably the generative nuclei (*fig. 133*).

* Rend. R. Accad. Lincei, 10: 168–172. 1901.

† Massart's contribution to this subject was not accessible and reference to it has of necessity been omitted.

But the actual conjugation of the oöspore with the male generative nucleus was not observed, nor could it be said that one of the synergids was not fertilized, though this seems improbable.

The pollen-tube in this family presents some interesting peculiarities. In most of the cases studied it proceeds straight through the micropyle to the embryo-sac. But in *Cyclanthera* and *Cucumis* the pollen-tube becomes dilated in the neck of the nucellus which extends through the micropyle and the surrounding cells are broken down to make way for it. This dilation is carried to an extreme in *Cucurbita Pepo*, which has recently been described by Longo.[54] In this case the tube branches and ramifies in different directions through the tissue of the integuments. The writer had hoped to treat more fully the subject of fertilization and the behavior of the pollen-tube in this paper, but the failure thus far to secure the best of material for such a study has rendered it expedient to leave this subject for a later contribution.

In the Cucurbitaceae great interest attaches to the behavior of the endosperm. The forms which this tissue assumes have already been described. As a rule the divisions of the endosperm nucleus occur before the first cleavage of the oöspore. Fusion of the polar nuclei must take place about the time of fertilization; in the cases where it was definitely observed it took place slightly before the appearance of the pollen-tube, and where the complete fusion was not apparent, numerous endosperm nuclei were to be seen while the embryo-sac was still undivided.

The appearance of starch in the embryo-sac at the time of fertilization is significant. It is not of general occurrence, but was found only in *Apodanthera*, *Bryonopsis*, *Luffa*, *Trichosanthes* and *Cucurbita*. Inasmuch, however, as starch is frequently of very transient duration it might have been overlooked in others. It is quickly formed as the embryo-sac approaches maturity and reaches its maximum before the appearance of the pollen-tube. No starch-grains were found in any case after the first division of the oöspore. In the case

of *Luffa*, *Trichosanthes* and *Bryonopsis* it will be observed that the starch appears before the fusion of the polar nuclei, though in the case of *Apodanthera* the fusion takes place before the formation of the starch. In *Cucurbita* the fusion-nucleus is seen in the midst of the starchy cytoplasm.

The source of this starch is a matter of much interest. Schleiden[75] states that the starch is brought to the ovule of *Cucurbita* by the pollen-tube, but here we find starch in the embryo-sac before the pollen-tube appears. D'Hubert[19] describes a condition in *Phyllocactus* in which starch is formed first in the antipodals and later disappears from these and accumulates in the free cytoplasm of the embryo-sac. Lloyd[53] reports an abundance of starch in *Galium* surrounding the polar nuclei and also in the antipodal cells. He finds it also in *Diodia* and *Houstonia* to some extent, though in the former it appears first in the antipodals and later in the endosperm. In either case it appears to be wanting until after fertilization.

It will be noted that in *Cucurbita* and the other cases cited the polar nuclei or the fusion-nucleus by their size and chromatic features exhibit a high degree of metabolic activity. The antipodals in some cases are prominent (*Trichosanthes*) and in others (*Cucurbita*, *Apodanthera*, *Luffa* and *Bryonopsis*) either partially disorganized or merely vestigial. Hence it is evident that the antipodals are not physiologically active at this stage. In those cases in which the fixation was accomplished by osmic acid mixtures, the presence of much oil was apparent in the tissue of the nucellus immediately surrounding the embryo-sac (*Cucumis*, *fig. 84*). The quantity of oil is greatest nearest the embryo-sac. The evidence at hand indicates that the oil is absorbed from these cells by the embryo-sac and becomes transformed into starch in the cytoplasm surrounding the polar nuclei.

The physiological equivalence of fats and carbohydrates is a fact well known. Pfeffer[70] points out that, during the germination of the oily seed of the cucumber, glucose is formed abundantly, and oil is formed from glucose in the ripening seed of *Ricinus*, but from starch in the endosperm

of *Paconia*. In the germination of the cocoanut starch is formed abundantly (Kirkwood and Gies[49]) from the reserve fats of the endosperm and this process is intra-cellular within the cotyledon. The absorption of fats then takes place, probably in an emulsified condition, through the cell-walls, and starch is formed from the products of their decomposition. It is not easy to determine, in a structure so small as an embryo-sac, the presence of an emulsifying or adipolytic ferment by an experimental process, but it seems probable that such may occur. However, in the case of the cocoanut no such agent has been detected.

It is evident that starch serves an important nutritive function in the subsequent growth of the endosperm. Its very transient character, and the immediate expansion of the endosperm as a whole, indicate that it is consumed in the process. It can hardly be regarded as a nutritive medium for the embryo directly, inasmuch as the oöspore exhibits very little growth until after the elongation of the endosperm, the multiplication of its nuclei and the disappearance of the starch. The development of the embryo begins only after the endosperm has displaced part of the tissue of the nucellus.

The general features of the growth and development of the endosperm in the Cucurbitaceae have been known for some time. Mirbel[59] (1815) observed that the perisperm in seeds of *Cucurbita* was very thin, that the cotyledons were large and broad. Again, in 1829,[60] he discusses the morphology of *Cucumis Anguria* and *C. leucantha*, and figures an ovule and the structures it contains after fertilization. In this particular case the endosperm occupies a large space in the nucellus and in form was ovoid with a tube-like prolongation at its lower end. The embryo at this stage he represented as narrow, pyriform, and about one-sixth the length of the endosperm.

Schleiden,[76] in the second edition of his *Grundzüge der wissenschaftliche Botanik*, describes an ovule of *Cucurbita Pepo* after fertilization and represents the embryo-sac as extending from micropyle to chalaza. In another work[75] (1845)

he states that the embryo-sac shows a chalaza-ward extension at about the time when the pollen-tube begins its distension in the micropyle. He further states that when the ovary has reached a length of about fifty millimeters the endosperm has begun to show a cellular structure. Garreau[27] (1849) studied *Momordica Elaterium* and *Cucumis sativus* and shows that in the former case the endosperm had replaced about half the tissue of the nucellus while the embryo was still only a spherical, undifferentiated mass of cells. Although he misunderstood some of the structures which he saw, he correctly represented the elongated mass of endosperm of *Cucumis* narrowed at its lower end. In this case the endosperm has begun to show a cellular structure in its upper portion while the embryo was still a pyriform mass of cells. Hofmeister[41] (1849) went further in his study of the endosperm of *Ecballium* (*Momordica*) *Elaterium*. He observed that the endosperm rapidly displaced the nucellus and that the embryo in turn displaced the endosperm. He further represented the vacuolated granular character of the endosperm cells and expresses the opinion that the process of development in the ovule of *Ecballium* was repeated in those of other members of the Cucurbitaceae.

The facts obtained in this study relative to the behavior of the endosperm have been recorded in each special case, and a comparison of the results will show that there is some degree of uniformity in the growth and development of the endosperm in the different species. It first expands into a sac-like body in the periphery of which are numerous free nuclei formed before the first division of the fertilized egg. The coenocytic condition is retained for some time and is gradually replaced by a cellular structure, first in the micropylar region. The expansion of the endosperm is rapid and always first in the direction of the chalaza. The most rapid expansion takes place usually in the coenocytic condition. The tissue of the nucellus is rapidly disorganized wherever the endosperm comes into contact with it. There seems to be no doubt that the nucellus is digested by ferments secreted

by the endosperm and that the embryo in its early stages is nourished by the products of this digestion, though not directly. Although anatomical evidence only is at hand on this question, the facts observed were all in harmony with the above conclusion. The endosperm grows at first at the expense of the embryo by utilizing the materials which it obtains for its own development, but when the embryo at a later time begins its growth it does not digest the endosperm, but apparently absorbs the material supplied by it. That the endosperm is only temporarily functional in this way is indicated by its appearance in those stages of embryonic development which follow the differentiation of cotyledons. At about this time the ovule has almost assumed the proportions of a ripe seed and the nucellus is able to offer no resistance to the growth of the embryo or to the flow of those nutritive substances which enter through the chalaza. The endosperm very early replaces most of the nucellar tissue and before the embryo is far along in its growth there is little of it left. The endosperm loses most of those plasmatic characters which indicate an active metabolism, and becomes of very thin and watery consistency.

That endosperm sometimes acts as a digestive medium in absorbing the tissue of the nucellus has been shown by Johnson,[47] in the case of certain species of the Piperaceae. Haustorial extensions of the endosperm are more or less common in many families among the Sympetalae. Balicka-Iwanowska[4] found in the Campanulaceae haustoria developed from the endosperm which penetrated the integuments of the ovule. From these and other observations the generalization was made that such haustoria were formed only in ovules with thick integuments. Other investigations in the Campanulaceae have been conducted by Hegelmaier.[30] He found that the endosperm of *Specularia* extends toward the chalaza in a string-like mass which may sometimes become divided by walls transversely and sometimes longitudinally. Other investigations on the Lobeliaceae and the Stylidiaceae reveal haustorial appendages of the embryo-sac which serve

a nutritive function. But such structures are not confined to the Sympetalae, for Miss Benson[5] has found in several members of the Amentiferae a vermiform extension of the embryo-sac which reaches toward the chalaza.

The form assumed by the embryo is remarkably uniform from the first. Usually two or three transverse divisions of the oöspore result in the formation of a proembryo and a rudimentary suspensor which lasts but a short time. Subsequent divisions proceed with no perceptible regularity until a globular or pyriform mass is formed. After this stage the embryo becomes broadened distally and the cotyledons appear. At the same time there is an internal marking off of root-cap and dermatogen. Subsequent growth develops the cotyledons and the growing point of the stem is organized very late.

In many of the sympetalous families the forms of the embryo are quite different from those in the Cucurbitaceae. In the Campanulaceae Tulasne[33] found that the oöspore of *Campanula* elongates to ten or twelve times its diameter, and then forms near its outer end two or three transverse walls, the terminal cell being the proembryo. In the Rubiaceae and in the Globulariaceae an extensive suspensor is developed. But the different degrees of development which the suspensor may reach is so varied throughout the angiosperms that this feature is of little value as a means of determining relationships.

As to the systematic position of the Cucurbitaceae, the facts at hand will hardly justify any sweeping conclusions. Too little is yet known of the exact course of intra-seminal development in this and in other families supposed to be closely related. Of the eighty or more genera of this family but a few have been carefully studied, and while these are quite representative and the results uniform, still it would no doubt be advantageous to know the conditions existing in some other members of the Fevilleae, *e. g.*, *Alsomitra* and *Zanonia*. This is desirable from the fact that *Fevillea* itself presents conditions less at variance with those found in others of the

Sympetalae, not only in the form and structure of its ovule but also in a certain character of its embryo-sac, viz., the increase in the number of antipodals. But in most points the differences between the Cucurbitaceae and other sympetalous families are more striking than the similarities, and include the form and structure of the ovule, the presence of a distinct tapetum and the ephemeral character of the antipodals.

Bibliography

1. **Amici, G. B.** Osservazioni microscopiche sopra varie piante. Atti Soc. Ital. Sci. **19**: —. Modena, 1823. Also Ann. Sci. Nat. **2**: 41–70, 211–248. 1824.

2. ———. Note sur le mode d'action du pollen sur le stigmate. (Extract from a letter to Mirbel.) Ann. Sci. Nat. **21**: 329–332. 1830.

3. **Baillon, H.** Cucurbitacées. Histoire des plantes, **8**: 375–. 1886,

4. **Balicka-Iwanowska, G.** Contribution à l'étude du sac embryonnaire chez quelques Gamopetales. Flora, **86**: 47–71. *pl. 3–10.* 1899.

5. **Benson, M. F.** Contributions to the embryology of the Amentiferae. Trans. Linn. Soc. II. **3**: 409–424. *pl. 67–72.* 1894.

6. **Bentham, G. & Hooker, J. D.** Cucurbitaceae. Genera plantarum, **1**: 816–841. 1867.

7. **Billings, F. H.** Beiträge zur Kenntniss der Samenentwickelung. Flora, **88**: 253–318. *f. 1–100.* 1901.

8. **Brongniart, A.** Mémoire sur la génération et développement de l'embryon dans les végétaux phanérogames. Ann. Sci. Nat. **12**: 14–53, 145–172, 225–296. *pl. 34–44.* 1827.

9. **Caldwell, O. W.** On the life history of *Lemna minor*. Bot. Gaz. **27**: 37–65. *f. 1–59.* 1899.

10. **Campbell, D. H.** Studies on the Araceae. Ann. Bot. **14**: 1–25. *pl. 1–3.* 1900.

11. ———. Studies on the flower and embryo of *Sparganium*. Proc. Cal. Acad. Sci. III. **1**: 293–328. *pl. 46–48.* 1899.

12. ———. Notes on the structure of the embryo-sac in *Sparganium* and *Lysichiton*. Bot. Gaz. **27**: 153–166. *pl. 1.* 1899.

13. ———. A peculiar embryo-sac in *Peperomia pellucida*. Ann. Bot. **13**: 626. 1899.

14. ———. Recent investigations upon the embryo-sac of Angiosperms. Am. Nat. **36**: 777–786. 1902.

15. **Cannon, W. A.** A morphological study of the flower and embryo of the wild oat, *Avena fatua* L. Proc. Cal. Acad. Sci. III. **1**: 329–355. *pl. 49–53.* 1900.

16. **Chamberlain, C. J.** The embryo-sac of *Aster Novae-Angliae*. Bot. Gaz. **20**: 205–212. *pl. 15, 16.* 1895.

17. **Cogniaux, A.** Cucurbitacées. In De Candolle, Monographiae Phanerogamarum, **3**: 325–951. 1881.

18. **Coulter, J. M. & Chamberlain, C. J.** Morphology of angiosperms. New York. 1903.

19. **D'Hubert, E.** Recherches sur le sac embryonnaire des plantes grasses. Ann. Nat. Sci. Bot. VIII. **2**: 37–128. *pl. 1–3. f. 1–66.* 1895.

20. **Dodel, A.** Beiträge zur Kenntniss der Befruchtungserscheinungen bei *Iris Sibirica*. Festschrift (Nägeli und Kölliker), Wurzburg. 1891.

21. **Eichler, A. W.** Cucurbitaceae. Blüthendiagramme, **1**: 302–321. 1875.

22. **Facchini, F.** [Amici's results on a study of *Cucurbita Pepo*.] Flora, **27**: 359–360. 1844.

23. ———. Ueber die Amici'sche Ansicht von der Befruchten der Pflanzen, ein Beitrag. Flora, **28**: 193–198. 1845.

24. **Gaertner, C. F.** Notice sur des expériences concernant la fécondation de quelques végétaux. Ann. Sci. Nat. **10**: 113–144. *pl. 12–17.* 1827.

25. **Gaertner, J.** De fructibus et seminibus plantarum, **2**: 45–50; **3**: *pl. 88.* 1791.

26. **Ganong, W. F.** The cardinal principles of morphology. Bot. Gaz. **31**: 426–434. 1901.

27. **Garreau, L.** Nature de la cuticle, ses relations avec l'ovule. Ann. Sci. Nat. III. **13**: 304–315. *pl. 9, 10.* 1849.

28. **Goebel, K.** Outlines of classification and special morphology, 392. Oxford edition, 1887.

29. ———. Vergleichende Entwickelungsgeschichte der Pflanzenorgane. In Schenk's Handbuch der Botanik, 3^1: 99–430. 1884.

30. ———. Zur Entwickelungsgeschichte des unterständigen Fruchtknotens. Bot. Zeit. **44**: 729–738. *pl. 5.* 1886.

31. **Goldflus, M.** Sur la structure et les fonctions de l'assise épithéliale et des antipodes chez les Composées. Jour. de Bot. **12**: 374–384. 1898; **13**: 9–17, 47–59, 87–96. *pl. 1–6.* 1899.

32. **Grew, N.** Anatomy of plants, 181. *pl. 66.* 1682.

33. **Guignard, L.** L'appareil sexual et la double fécondation dans les Tulipes. Ann. Sci. Nat. Bot. VIII. **11**: 365–384. *pl. 9–11.* 1900.

34. ———. Recherches sur la developpement de la graine. Jour. de Bot. **7**: 1–14, 21–34, 57–66, 97–106, 141–153, 205–214, 241–250, 282–296, 303–311. *f. 1–158.* 1893.

35. ———. Recherches d'embryogénie végétale comparée. I. Legumineuses. Ann. Sci. Nat. Bot. VI. **12**: 5–166. *pl. 1–8.* 1881.

36. ———. La double fécondation chez les Solanacées. Jour. de Bot. **16**: 145–167. 1902.

37. **Harz, C. O.** Landwirthschaftliche Samenkunde, 767–824. Berlin, 1855.

38. **Hegelmaier, F.** Zur Entwickelungsgeschichte endospermatischer Gewebekörper. Bot. Zeit. **44**: 529–539, 545–555, 561–578, 585–595. *pl. 4.* 1886.

39. ———. Untersuchungen über die Morphologie des dicotyledonen Endosperms. Nova Act. Akad. Naturforscher, **49**: 1–104. *pl. 5.* 1885.

40. **Hofmeister, W.** Neue Beiträge zur Kenntniss der Embryobildung der Phanerogamen. Leipzig. 1859–61.

41. ———. Die Entstehung des Embryo der Phanerogamen. Leipzig. 1849.

42. ———. Lehre von der Pflanzen-zelle. 1867.

43. ———. Neuere Beobachtungen über Embryobildung der Phanerogamen. Jahrb. Wiss. Bot. **1**: 82–188. *pl. 7–10.* 1858.

44. **Ikeda, T.** Studies in the physiological functions of antipodals and related phenomena of fertilization in the Liliaceae. Bull. Coll. Agric. Imp. Univ. Tokyo, **5**: 41–72. *pl. 3–6.* 1902.

45. **Johnson, D. S.** On the endosperm and embryo of *Peperomia pellucida.* Bot. Gaz. **30**: 1–10. *pl. 1.* 1900.

46. ———. On the development of *Saururus cernuus* L. Bull. Torrey Club, **27**: 365–372. *pl. 23.* 1900.

47. ———. On the development of certain Piperaceae. Bot. Gaz. **34**: 321–340. *pl. 9–10.* 1902.

48. **Juel, H. O.** Vergleichende Untersuchungen über typische und parthenogenetische Fortpflanzung bei der Gattung *Antennaria.* Kongl. Svenska Vet.-Akad. Handl. **3**: 1–59. *pl. 1–6.* 1900.

49. **Kirkwood, J. E. & Gies, W. J.** Chemical studies on the cocoanut, with some notes on the changes during germination. Bull. Torrey Club, **29**: 321–359. *pl. 19.* 1902.

50. **Koernicke, M.** Studien an Embryosack-Mutterzellen. Sitzungsber. der Niederrhein. Gesellsch. Natur- und Heilkunde zu Bonn. 1901.

51. **Koorders, S. H.** Die Keimotwickeling van *Tectonia grandis* (Djati). Natuurk. Tijdschr. voor Ned. Ind. III. **12**: 139. *pl. 1–8.* 1892.

52. **Lestiboudois, T.** Carpographie anatomique. Ann. Sci. Nat. Bot. IV. **2**: 223–243. *pl. 16–17.* 1854.

53. **Lloyd, F. E.** The comparative embryology of the Rubiaceae. Mem. Torrey Club, **8**: 1–112. *pl. 1–15.* Part I. 1899. Part II. 1902.

54. **Longo, B.** Richerche sulle Cucurbitaceae e il significato del percorso intercellulare (endotropico) del tubetto pollinico. R. Accad. dei Lincei, **30**: 523–547. *pl. 1–6.* 1903.

55. **Mann, G.** Criticism of the views with regard to the embryo-sac of angiosperms. Trans. & Proc. Bot. Soc. Edinb. **19**: 136–148. 1891.

56. ———. The embryo-sac of *Myosurus minimus* L. A cell study. Trans. & Proc. Bot. Soc. Edinb. **19**: 351–428. *pl. 3, 4.* 1892.

57. **Martin, G. W.** Development of the flower and embryo-sac in *Aster* and *Solidago*. Bot. Gaz. **17**: 353–357, 406–411. *pl. 19, 20.* 1892.

58. **Merrell, W. D.** A contribution to the life history of *Silphium*. Bot. Gaz. **29**: 99–133. *pl. 3–10.* 1900.

59. **Mirbel, C. F. B.** Élémens de physiologie végétale. **2**: 903–904. *pl. 52.* 1815.

60. ———. Nouvelles recherches sur la structure et les développement de l'ovule végétale. Ann. Sci. Nat. **17**: 302–318. *pl. 12–16.* 1829.

61. ———. Complément des observations sur le *Marchantia polymorpha*. Mém. Inst. France, **13**: (39–74) *pl. 8–10.* 1835.

62. **Miyoshi, M.** Ueber Reizbewegungen der Pollen-schläuche. Flora, **78**: 76–93. 1894.

63. **Molisch, H.** Zur Physiologie des Pollens mit besonderer Rücksicht auf die chemotropischen Bewegungen der Pollenschläuche. Sitzungsber. K. Acad. Wis. Wien, **102**: 423–448. 1893.

64. **Müller, E. G. O. & Pax, F.** Cucurbitaceae. In Engler & Prantl, Die natürliche Pflanzenfamilien, 4^5: 1–39. *pl. 4–8.* 1894.

65. **Murbeck, S.** Anomalien in Baue des Nucellus und des Embryo-sacks bei parthenogenetischen Arten der Gattung *Alchemilla*. Lunds Univ. Årsskrift, 38^2: 1–10. *pl. 1.* 1902.

66. **Naudin, C.** Organographie végétale. Ann. Sci. Nat. IV. **4**: 5–19. *pl. 1, 2.* 1855.

67. ———. Espèces et variétés du genre *Cucurbita*. Ann. Sci. Nat. IV. **6**: 5–73. 1856.

68. ———. Espèces et varieties nouvelles de Cucurbitaceae. Ann. Sci. Nat. IV. **18**: 159–208. 1862.

69. **Nawaschin, S.** Ueber die Befruchtungsvorgänge bei einigen Dicotyledoneen. Ber. Deut. Bot. Gesells. **18**: 224–230. *pl. 9.* 1900.

70. **Pfeffer, W.** Physiology of plants. Oxford Edition. 1900.

71. **Roze, E.** Le fruit de l'*Ecballium Elaterium* Rich. (*Momordica Elaterium* L.). Jour. de Bot. **8**: 308–318. 1894.

72. **Sageret, A.** Considérations sur la production des hybrides, des variantes et des variétés in général, et sur celles de la famille des Cucurbitacées en particulier. Ann. Sci. Nat. **8**: 294–314. 1826.

73. **Schaefer, B.** Beiträge zur Entwickelungsgeschichte des Fruchtknotens und der Placenten. Flora, **73**: 62–104. *pl. 3–6.* 1890.

74. **Schleiden, M. J.** Bemerkung zur Bildungsgeschichte des vegetabilischen Embryo. Flora, **27**: 787–789. 1844.

75. ———. Ueber Amici's letztern Beitrag zur Lehre von der Befruchtung der Pflanzen. Flora, **28**: 593–600. *pl. 6.* 1845.

76. ———. Grundzüge der wissenschaftliche Botanik. Aufl. 2, 251. 1846.

77. **Schnegg, H.** Beiträge zur Kenntniss der Gattung *Gunnera*. Flora, **90**: 161–208. *f. 1–28.* 1902.

78. **Solms-Laubach, H. Graf zu.** Ueber monocotyle Embryonen mit scheitelbürtigem Vegetationspunkt. Bot. Zeit. **36**: 65–74, 82–93. *pl. 4.* 1878.

79. **Strasburger, E.** Die Angiospermen und Gymnospermen. Jena. 1879.

80. **Tieghem, P. van.** Recherches sur la structure du pistil. Ann. Sci. Nat. V. **9**: 127–226. *pl. 9–12.* 1868.

81. **Tison, E.** Recherches sur les caractères de la placentation et de l'insertion dans les Myrtacées. Paris. 1876.

82. **Treub, M.** Notes sur l'embryogénie de quelques Orchidées. Verhand. Akad. Wetensch. **19**:—. 1879.

83. **Tulasne, L. R.** Études d'embryogénie végétale. Ann. Sci. Nat. III. **12**: 21–137. *pl. 3–7.* 1849.

84. **Tretjakow, S.** Die Betheiligung der Antipoden in Fällen der Polyembryonie bei *Allium odorum* L. Ber. Deut. Bot. Gesell. **13**: 13–17. *pl. 2.* 1895.

85. **Ward, H. M.** A contribution to our knowledge of the embryo-sac of angiosperms. Proc. Linn. Soc. Lond. **17**: 519–546. *pl. 17–25.* 1880.

86. **Warming, E.** De l'ovule. Ann. Sci. Nat. Bot. VI. **5**: 177–266. *pl. 7–13.* 1878.

87. **Webber, H. J.** Xenia, or the immediate effect of pollen, in maize. U. S. Dept. Agric., Div. Veg. Path. & Phys., Bull. No. 22. 1900.

88. **Westermaier, M.** Zur Embryologie der Phanerogamen insbesondere über die sogenannten Antipoden. Nova Acta Akad. Caes. Leop. Carol. 57: 1–39. *pl. 1–3.* 1892.

89. ———. Zur Physiologie und Morphologie der Angiospermen-Samenknospe. Beitr. Wiss. Bot. 1: 255–280. *pl. 5, 6.* 1896.

Key to the Lettering of Text-Figures and Plates

c, carpel.
n, nucellus.
o, placenta.
p, petal.
s, sepal.
st, staminodium.
sl, stigmatic lobe.
x, pistillate flower.
ii, inner integument.
oi, outer integument.
h, haustorium.
pt, pollen-tube.
en, endosperm.

Explanation of Plates 58-69

Fevillea cordifolia (Plates 58 and 59).

1. Apex of shoot, showing origin of pistillate flowers. × 60.
2. Cellular structure of the apex. × 184.
3. Rudiment of a pistillate flower. × 184.
4. Later stage of same, showing origin of sepals. × 184.
5. Ditto, showing origin of petals.
6. Outline sketch of later stage, showing origin of carpels and staminodia. × 60.
7. Transverse section through young ovary, showing origin of the placentae. × 144.
8. Placenta and ovule. × 60.
9. Archesporial cell. × 440.
10. Showing condition of nucellus. × 184.
11. Primary sporogenous cell and tapetum. × 440.
12. Spore-mother-cell deep in tissue of nucellus. × 440.
13. Form of ovule, longitudinal section. × 60.
14. Megaspore-mother-cell. Metaphase of first division. × 920.
15. Ditto, after first division. × 920.
16. Four megaspores; lowermost one functional. × 920.
17. Embryo-sac of four cells. × 440.
18. Embryo-sac approaching maturity. × 440.
19. Definitive embryo-sac. × 480.
20. Embryo-sac and upper part of endosperm. × 440.
21. Portion of nucellus showing extent of endosperm. × 40.
22. Embryo and endosperm. × 440.

23. Embryo and endosperm. × 184. Endosperm somewhat disintegrated.

24. Embryo. × 440.

Melothria pendula (PLATES 59 AND 60).

25. Megaspore-mother-cell. Origin of inner integuments, *ii*. × 440.

26. Four-celled embryo-sac. × 440.

27. Embryo-sac near maturity. × 440.

28. Embryo and endosperm. × 440.

29. Ditto, slightly later. × 440.

30. Embryo. × 440.

31. Embryo of 14 to 16 cells. × 440.

32–34. Embryos of various stages. Magnified 440, 324 and 184 times respectively.

Apodanthera undulata (PLATE 60).

35. Definitive embryo-sac. × 440.

36. Endosperm showing starch. × 440.

37–38. Embryos. × 440.

39. Apex of nucellus, pollen-tube, embryo and endosperm. Haustorial extension of endosperm. × 184.

40. Embryo of 39, enlarged. × 440.

41. Anatomical relations of nucellus, embryo and endosperm. × 30.

42. Apical region of radicle of young embryo, showing some differentiation of root-cap and dermatogen. × 184.

43. Same embryo showing region, from which stem apex is formed. × 184.

43*a*. Schematic representation of same embryo.

Bryonopsis laciniosa erythrocarpa (PLATE 61).

44. Apex of nucellus showing primary sporogenous cell. × 312.

45. Ditto, later. × 312.

46. Megaspores, functional one longest. × 312.

47. Two-celled embryo-sac. × 440.

48. Embryo-sac of eight cells before migration of polar nuclei. × 440.

49. Embryo-sac near definitive stage. Starch-grains abundant. × 440.

50. Embryo-sac after fertilization. Oöspore and endosperm with scattered starch-grains. × 440.

51. Embryo and contiguous endosperm. × 440.

Trichosanthes Anguina (PLATE 61).

52. Apex of nucellus showing archesporial cell. × 440.

53. Primary sporogenous cell and tapetal layers. × 440.

54. Concluding stage in second division of the sporogenous cell. Divisions apparently suppressed in the other cell. × 440.

55. Megaspore. Non-functional ones represented by black mass. × 440.

56. Embryo-sac showing starch content. × 440.

57. Two-celled embryo and upper portion of endosperm. × 440.

58. Four-celled embryo. × 440.

59. Outline sketch showing proportions of nucellus, embryo and endosperm. × 40.

60. Portion of endosperm from same. × 440.

61. Embryo from 59. × 184.

62. Embryo and endosperm. × 40.

Momordica Charantia (PLATES 61 AND 62).

63. Young ovule showing megaspore-mother-cell. × 184.

64. Megaspore-mother-cell. × 440.

65. Embryo-sac of two cells.

66, 66*a*. Different sections through the same embryo-sac. × 440.

67. Pollen-tube, embryo, and endosperm. × 440.

68. Embryo and endosperm. × 184.

69. Embryo, pollen-tube and endosperm. × 36.

70. Embryo, cellular endosperm. × 440.

71. Showing relative proportions of embryo, endosperm and ovular tissue. × 36.

Luffa acutangula (PLATES 62 AND 63).

72, 73, 74. Megaspore-mother-cells at different ages. × 440.

75. Megaspores, functional one largest. × 440.

76. Two-celled embryo-sac. × 440.

77. Four-celled embryo-sac. × 440.

78. Eight-celled embryo-sac. × 440.

79. Embryo-sac near maturity. × 440.

80. Oöspore and endosperm containing scattered starch-grains. Disintegrating nucellar cells. × 440.

81. First division of oöspore completed.

Cucumis myriocarpus (PLATES 63 AND 64).

82. Primary sporogenous cell and tapetum. × 440.

83. Telophases of the second division of the megaspore-mother-cell. × 440.

84. Embryo-sac near the definitive stage. × 440.

85. Representing embryo of three cells. × 440.

86. Similar to 85. × 440.

87. Young embryo and endosperm. × 440.

88. Embryo, endosperm and pollen-tube. Showing effect of endosperm on cells of nucellus. × 184.

89. Embryo of same. × 440.

90. Embryo. × 440.

91. Embryo, endosperm and nucellus. × 40.

92. Apical region of radical end of embryo from 91. × 440.

93. Portion of endosperm; the large cells are at the center of the mass, the small ones at the periphery. × 440.

Lagenaria Lagenaria (PLATE 64).

94. Apex of young ovule before differentiation of archesporium. × 440.

95. Sporogenous cell and tapetum. × 114.

96. After first division of megaspore-mother-cell. × 440.

97. Four megaspores. × 440.

98. Mitoses of the embryo-sac nuclei preceding eight-cell stage. × 440.

99–100. Stages approaching definitive embryo-sac. Showing aggregation of starch. × 440.

101. Illustrating first division of oöspore and young endosperm. × 440.

102. Embryo of five or six cells. × 440.

103. Young embryo and cellular endosperm. × 440.

104. Endosperm, embryo and part of nucellus. × 184.

105. Diagrammatic sketch showing relative proportions of embryo, endosperm, and nucellus. × 40.

106. Same embryo with upper part of endosperm. × 184.

107. Older embryo. × 184.

Benincasa hispida (PLATE 65).

108. Apex of very young ovule before formation of archesporium. × 440.

109. Megaspore-mother-cell and tapetum. × 440.

110. Four-celled embryo-sac. × 440.

111. Eight-celled embryo-sac. × 440.

112. Nearly mature embryo-sac. × 440.

113. Oöspore and endosperm. × 440.

114. Ditto, slightly later. × 440.

115. Showing lines of cleavage in embryo. × 440.

116. Endosperm and disintegrating nucellus. × 440.

Citrullus Citrullus (PLATES 65 AND 66).

117. Apex of nucellus; primary sporogenous cell and tapetum. × 312.

118. Process of formation of megaspores. × 440.

119–121. Two, four, and eight-cell stages in embryo-sac formation. × 440.

121–122*a*. Different aspects of the embryo-sac near time of maturity. Oöspore omitted from 122*a*. × 440.

123. Oöspore and growing endosperm. × 440.

124. Diagram of embryo, endosperm and nucellus; *V*, representing "pocket" of cells around end of haustorium. × 40.

125. Embryo and upper part of endosperm indicated in 124. × 440.

126. Showing terminal portion of haustorium and structure of "pocket." × 312.

Cucurbita Pepo (PLATES 66 AND 67).

127. Primary sporogenous cell and tapetum (?). × 440.

128. Same at later stage (megaspore-mother-cell). × 440.

129. After first division of megaspore-mother-cell. × 440.

129*a*. The four megaspores. × 440.

130. Four-celled embryo-sac. × 440.

131. Embryo-sac of eight cells. Early stages in differentiation of parts. × 440.

132. Definitive embryo-sac containing starch. Antipodals vestigial. × 440.

133. Apex of pollen-tube as it appears in the micropyle. × 440.
134. Oöspore and young endosperm. × 440.
135. Showing relative extent of endosperm in the same case as 134. × 160.
136. Showing form and structure of the endosperm. × 312.
137. Embryo-sac (crook-neck squash) near maturity. × 440.
138. Young embryo (Chile squash). × 440.

Coccinia cordifolia (PLATE 67).

139. Megaspore-mother-cell and tapetum. × 440.
140. Four-celled embryo-sac. × 440.

Sicyos angulata (PLATE 67).

141. Nucellus and inner integuments. Megaspore-mother-cell after first division. × 184.
142. Embryo-sac of four cells. × 440.
143. Embryo-sac of eight cells. × 440.
144. Embryo-sac, almost mature. × 480.
145. Young embryo and endosperm. × 440.
146. Pollen-tube, embryo and endosperm. × 184.
147. Showing progress of endosperm formation. × 312.

Micrampelis lobata (PLATES 68 AND 69).

148. Nucellus and spore-mother-cell. × 184.
149. Telophase of first division of spore-mother-cell. × 440.
150–151. Two-celled embryo-sacs of slightly different ages. × 440.
152. Embryo-sac of four cells. × 440.
153. Embryo-sac of eight cells. × 312.
154. Showing process of differentiation in the embryo-sac of eight cells. × 440.
155. Embryo-sac near maturity.
156. Young embryo and endosperm. Showing also remnant of a synergid and the pollen tube. × 312.
157. Slightly later stage than 156. Embryo of about ten cells. × 312.
158. Embryo and endosperm. Characteristic appearance of endosperm in the early stages of embryonic development. × 120.
159. Later stage in the development of embryo and endosperm. × 36.

Cyclanthera explodens (PLATE 68).

160. Apex of young nucellus about the time of the appearance of the archesporium. × 440.
161. Spore-mother-cell and tapetum. × 440.
162. Showing the megaspore and its position with reference to the apex of the nucellus. × 440.
163. Embryo-sac of two cells. × 440.
164. Embryo-sac nearly mature. × 440.
165. Young embryo-sac and endosperm. × 440.
166. Showing form of ovule, the pollen-tube, the endosperm and the portion of the nucellus disorganized. × 40.

Additions to the Palaeobotany of the Cretaceous Formation on Long Island. No. II.*

By Arthur Hollick.

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I. INTRODUCTION

In two previous contributions† an attempt was made to give an account of all that was known or recorded in regard to the fossil flora of the Cretaceous formation on Long Island. Since these were published the investigation of the subject has been continued from time to time, as circumstances permitted, and incidental references may be found in subsequent papers on the geology of the region.‡

The present contribution may be regarded as a continuation of this work, based upon investigations made during the years 1903 and 1904, largely in the vicinity of Northport and on Manhassett Neck. The former locality, and points of interest in connection with it, are described in detail under a separate heading. At the latter locality the exposure of Cretaceous material consists of clays and sands, very much disturbed by glacial action and more or less in-

* [Investigations prosecuted with the aid of a grant from the Botanical Society of America.]

†1. Preliminary contribution to our knowledge of the Cretaceous formation on Long Island and eastward. Trans. N. Y. Acad. Sci. **12**: 222–237. *pl. 5–7*. 1893.

2. Additions to the palaeobotany of the Cretaceous formation on Long Island. Bull. Torrey Club, **21**: 49–65. *pl. 174–180*. 1894.

‡1. Some further notes on the geology of the north shore of Long Island. Trans. N. Y. Acad. Sci. **13**: 122–129, and table of distribution. 1894.

2. Geological notes: Long Island and Nantucket. Trans. N. Y. Acad. Sci. **15**: 3–10. 1895.

3. Geological notes: Long Island and Block Island. Trans. N. Y. Acad. Sci. **16**: 9–18. 1896.

volved with the moraine. On the east side of the neck, or in other words on the west side of Hempstead Harbor, these exposures may be seen in road cuttings and on the shore, especially in the vicinity of Mott's Point. Ferruginous shale and concretions, in all respects similar to the material found on the opposite shore of the harbor, at Sea Cliff and Glen Cove, are abundantly represented, both in connection with the Cretaceous exposure and as scattered morainal material. It was in these concretions and fragments of shale that the fossil plant remains were found. So far as I am aware there is no previous record of fossil plants having been discovered at this locality, although their occurrence was to be expected, as it is directly on the line of strike between Glen Cove to the east and Elm Point on Great Neck to the west, at both of which places there are outcrops of Cretaceous clays, accompanied by ferruginous shales containing leaf impressions and a knowledge of these conditions was what led to the exploration of Manhassett Neck.

I am indebted to Mr. A. E. Anderson for the opportunity to examine and describe specimens in his possession and to Mr. A. C. Veatch, Mr. H. S. Shimer and Miss Florence Henry (now Mrs. H. S. Shimer), for assistance in the field.

II. FOSSIL FLORA OF THE NORTHPORT CLAYS

General character of the plant-bearing deposits

The beds containing fossil plants in the vicinity of Northport are located on Little Neck, which forms the western shore of Northport Bay. They consist of stratified clays and sands, of Cretaceous age, overlain by more recent sands and gravels and a limited amount of glacial till. The strata are exposed on the eastern side of the neck, where the clay and sand has been excavated for commercial purposes. There is some indication of disturbance in the deposits as a whole, as if they had been subjected to lateral pressure, but a general S. E. dip is apparent in the portion exposed. Plant remains are abundant in certain layers, but as a rule they are either fragmentary or else they are contained in fine, sandy clay, from which specimens in good condition are exceedingly difficult to obtain.

Previous investigations

In the Transactions of the New York Academy of Sciences,* Mr.

* Notes on the clays of New York State and their economic value. Trans. N. Y. Acad. Sci. 12: 40–47. 1892.

Heinrich Ries briefly mentions these deposits and says, on page 45: "The owner claims to have frequently dug up leaves"; and later,* on page 166: "The writer has found leaves (referable to *Eucalyptus*) in the clays at Northport." Subsequently the locality was personally visited in company with Mr. Ries and a few specimens were found, which were provisionally determined and listed, in a paper by Mr. Ries in the School of Mines Quarterly.† These determinations were hastily made and unfortunately the matrix was such that it disintegrated and all but one or two of the specimens were destroyed. The species determined were: *Paliurus integrifolius* Hollick, *Paliurus* sp.?, *Laurus angusta* Heer, *Protaeoides daphnogenoides* Heer, *Myrsine* sp.?, *Williamsonia* sp.?, and *Celastrophyllum* sp.? Those that were found to be sufficiently well preserved have been recently subjected to more careful examination and are included, with those subsequently collected, in the figured descriptions which follow.

Descriptions of species

Dammara Northportensis sp. nov.

(Plate 70, figs. 1, 2.)

Scales rounded kite-shaped, about 8 mm. long by 7–9 mm. wide at top; incurved above, narrowed to an obtuse base and provided with small elongated resin ducts.

These little cone-scales are referred to the genus *Dammara*, in common with other similar organisms (*D. borealis* Heer, Fl. Foss. Arct. **6**[2]: 54. *pl. 37, f. 5; D. microlepis* Heer, *ibid.* 55. *pl. 40, f. 5; D. Cliffwoodensis* Hollick, Trans. N. Y. Acad. Sci. **16**: 128. *pl. 11, f. 5–8.* 1897), although their true affinities are probably with other coniferous genera, represented in the flora by leafy twigs and branches. Newberry was inclined to consider certain similar remains as belonging to *Juniperus macilenta* Heer, or some conifer closely closely resembling it (Fl. Amboy Clays, Monog. U. S. Geol. Surv. **26**: 47), but until the actual association of cones and branches has been definitely determined it would seem wiser to include all these scales under one generic name.

* Microscopic organisms in the clays of New York State. *Ibid.* **13**: 165–169. *pl. 3, 4.* 1894.

† On the occurrence of Cretaceous clays at Northport, L. I. S. of M. Quart. **15**: 353, 354. 1894.

Our specimens are smaller than any of those previously described and they are apparently incurved rather than rounded or mucronate above.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

BRACHYPHYLLUM MACROCARPUM Newb.

(PLATE 70, FIGS. 4, 5.)

Brachyphyllum macrocarpum Newb. (Fl. Amboy Clays) Monog. U. S. Geol. Surv. **26**: 51, footnote. 1895 [1896].— Knowlton (Cat. Cret. and Tert. Plants N. Am.) Bull. U. S. Geol. Surv. 152: 51. 1898.

Thuites crassus Lesq. Cret. and Tert. Fl. 32. 1883 [1884].

Brachyphyllum crassum Lesq. Proc. U. S. Nat. Mus. **10**: 34. 1887. Not *B. crassum* Tenison-Woods, Proc. Linn. Soc. N. S. Wales, **7**: 660. 1883.

This species may be found, described and figured as *B. crassum* by Lesquereux, in his Flora of the Dakota Group (Monog. U. S. Geol. Surv. **17**: 32. *pl. 2, f. 5*) from Kansas, and by Newberry, in his Flora of the Amboy Clays (Monog. U. S. Geol. Surv. **26**: 51. *pl. 7, f. 1–7*) from South Amboy, New Jersey. The specific name *crassum* was however subsequently found to be antedated, having been applied by Tenison-Woods to a different plant, and Newberry's manuscript name *macrocarpum* was adopted by Knowlton, as cited above.

I am also inclined to consider it as identical with *Echinostrobus squamosus* Vel. (Gymnosp. Boehm. Kreideform. 16. *pl. 6, f. 3, 6–8*) from Bohemia, but Newberry evidently considered them as distinct and merely refers to their "striking resemblance" (Fl. Amboy Clays, 53). The species has not heretofore been reported from Long Island.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Caulinites inquirendus sp. nov.

(PLATE 70, FIG. 3.)

Remains consisting of small spherical seeds, spore-cases or capsules, attached singly or in clusters to the slender branches of an irregularly forking or branching raceme.

The botanical affinities of this organism are uncertain, but there

can hardly be any question in regard to its relationship with *Caulinites fecundus* Lesq. (Tert. Fl. 101. *pl. 14, f. 1–3*), which Knowlton has transferred to the ferns (*Onoclea fecunda* (Lesq.) Kn. Bull. U. S. Geol. Surv. 152: 153). In fact, if Lesquereux's species had been described from the same geological horizon as ours I could hardly have questioned their specific identity. It is also almost certainly identical with the fragment described and figured by me from Glen Cove, N. Y. (Bull. Torrey Club, **21**: 63. *pl. 180, f. 11*).

Similar remains have been described and figured by Heer as the fertile fronds of ferns, and it may be that such reference is correct. In this connection it is of interest to compare our figure with those of *Thyrsopteris Maakiana* Heer (Fl. Foss. Arct. 4 (Beitr. Jura-Fl.): *pl. 1, f. 1b; pl. 2, f. 5, 5b*), *T. gracilis* Heer (*ibid. pl. 1, f. 5*), *T. Murrayana* Heer (*ibid. pl. 1, f. 4b, c; pl. 2, f. 4, 4b*) and *Dicksonia clavipes* Heer (*ibid. pl. 2, f. 7, 7b*) from the Jurassic flora of Siberia, and with *Osmunda Oebergiana* Heer (Fl. Foss. Arct. 3 (Kreide-Fl.): *pl. 26, f. 9d*) from the Cretaceous of Greenland. The latter is particularly suggestive in its appearance and it occurs at a geological horizon that is practically the equivalent of that represented on Long Island.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Cocculus minutus sp. nov.

(Plate 70, fig. 6.)

Leaf small, about 12 mm. long by 4.5 mm. wide in the middle, elongated-elliptical (?), narrowly wedge-shaped below, entire, 3-nerved from the base; lateral primaries relatively close to the margin, with exceedingly thin secondaries extending upward at acute angles from the outer side and others connecting on the inner side with the midrib at approximately right angles.

This leaf, although much smaller, resembles very closely *C. cinnamomeus* Vel. (Fl. Boehm. Kreideform. (Part IV) 4 [65]. *pl. 8 [31], f. 16–21*) and may belong to the same species, as Velenovsky's figures indicate that the leaves vary considerably in size.

Collected by Mr. Heinrich Ries and originally determined by me as probably a new species of *Paliurus* (S. of M. Quarterly, **15**: 354).

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Laurus angusta Heer

(Plate 70, figs. 10, 11.)

Laurus angusta Heer, Fl. Foss. Arct. **6**[2]: 76. *pl. 20, f. 1b, 7; pl. 43, f. 1c.*

This species closely resembles *Laurophyllum angustifolium* Newb. (Fl. Amboy Clays, Monog. U. S. Geol. Surv. **26**: 86. *pl. 17, f. 10, 11*), but Heer's figures, especially his *f. 7*, appear to more nearly match ours.

Collected by Mr. Heinrich Ries.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Celastrus arctica Heer

(Plate 70, figs. 12, 13.)

Celastrus arctica Heer, Fl. Foss. Arct. **7**: 40. *pl. 61, f. 5d, e.*

This species although quite common in the Amboy clays of New Jersey has not heretofore been reported from Long Island.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Paliurus integrifolius Hollick

(Plate 70, fig. 7.)

Paliurus integrifolius Hollick, Bull. Torrey Club, **21**: 57. *pl. 177, f. 5, 8, 12.*

This is apparently a small specimen of the species, similar to *f. 5* above quoted, from Lloyd's Neck, Long Island.

Collected by Mr. Heinrich Ries.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

Eucalyptus (?) angustifolia Newb.

(Plate 70, figs. 8, 9.)

Eucalyptus (?) angustifolius Newb. (Fl. Amboy Clays) Monog. U. S. Geol. Surv. **26**: 111. *pl. 32, f. 1, 6, 7.*

Our specimens agree with Newberry's *f. 6* and *f. 7*, above quoted, but not with his *f. 1*, which apparently should not be included in the same species. It was probably leaves of this species that Ries mentions as "referable to *Eucalyptus*," in Trans. N. Y. Acad. Sci. **13**: 166, previously quoted.

Formation and locality: Cretaceous clay; Northport, Long Island, N. Y.

III. DESCRIPTIONS OF FOSSIL PLANTS FROM THE VICINITY OF HEMPSTEAD HARBOR, OYSTER BAY AND MONTAUK POINT

Marsilea Andersoni sp. nov.

(PLATE 71, FIGS. 1–3.)

Organism having the appearance of an orbicular, peltate leaf, about 6.5 cm. in diameter, with entire margin and finely flabellate, obscurely reticulated (?) nervation.

For some time I was quite uncertain in regard to the probable botanical affinities of these fragmentary specimens. The most complete one, represented by FIG. 1, has the general appearance of having been an entire, peltate leaf, similar to *Nelumbo* or *Brasenia*, but the nervation is of a totally different type. This is strongly suggestive of the fossil genera *Sagenopteris* or *Marsilidium*, supposed to be related to *Marsilea*, all of which, however, have compound leaves. Nevertheless, a comparison with flattened herbarium specimens of the latter, in which the leaflets are closely pressed together and more or less folded or overlapped, shows a striking superficial resemblance to our fossils, as may be seen by comparing them with PLATE 71, FIGS. 4, 5, 6, which represent leaves of *Marsilea Höltingiana* Schaff., a living species from Mexico. In these figures the overlapping marginal outlines of the leaflets are much more distinctly indicated than they actually appear in the herbarium specimens, in which they are very obscure and are more or less confused with the nervation.

I am inclined to think that a fragment similar to our fossils, collected on Chappaquidick Island and identified by me provisionally as *Thinnfeldia variabilis* Vel. (Bull. N. Y. Bot. Gard. **2**: 403. *pl. 41, f. 12.* 1902) may belong to the same species. In this fragment, reproduced in PLATE 71, FIG. 7, the nervation is well defined and may be seen to be almost exactly that of *Marsilea*, and it is an interesting coincidence that Dr. Edwin Bayer has referred *Thinnfeldia variabilis* Vel. to the genus *Sagenopteris* and mentions the occurrence, in association with it, of the fruit of *Marsilea* (Fric & Bayer, Studien im Gebiete der böhmischen Kreideformation. Perucer Schichten, 86. 1900).

The specimens were collected by Mr. A. E. Anderson, after whom the species is named.

Formation and locality: Cretaceous shale; Manhassett Neck, Long Island, N. Y.

PODOZAMITES ANGUSTIFOLIUS (Eichw.) Schimp.

(PLATE 71, FIG. 8.)

Podozamites angustifolius Schimp. Paléont. Végét. 2: 160.

Zamites angustifolius Eichw. Lethaea Rossica, 2: 39. *pl. 2, f. 7*.

A number of fragments, referred provisionally to the genus *Podozamites*, have been found on Staten Island, Long Island, Block Island and Martha's Vineyard, but this is the only specimen in which specific identification has been satisfactory. It is not rare in the Cretaceous of New Jersey and may be found described and figured by Newberry in the Flora of the Amboy Clays (*l. c.* 44. *pl. 13, f. 1–4*).

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

SEQUOIA sp.

(PLATE 72, FIG. 2.)

This specimen is too imperfect for any except generic determination, although it might be more or less satisfactorily compared with some one or another of several species, according to the particular figure selected, as for example, *S. subulata* Heer (Fl. Foss. Arct. 3 (Kreide-Fl.): *pl. 34, f. 1a; ibid.* 6^2: *pl. 17, f. 1*), *S. Reichenbachi* (Gein.) Heer (Fl. Foss. Arct. 3 (Kreide-Fl.): *pl. 12, f. 7d; pl. 20, f. 7a; pl. 22, f. 5f; pl. 36, f. 1–8*), *S. fastigiata* (Sternb.) Heer (Fl. Foss. Arct. 3 (Kreide-Fl.): *pl. 27, f. 5, 6; pl. 38, f. 13*), *S. concinna* Heer (Fl. Foss. Arct. 7: *pl. 51, f. 9; pl. 53, f. 1b*) or *S. condita* Lesq. (8th Ann. Rept. U. S. Geol. and Geog. Surv. Terr. *pl. 4, f. 7*).

Of the above species the only one definitely recorded from this region is *S. Reichenbachi*, which has been found at Cliffwood and Woodbridge, New Jersey, and on Staten Island, but no representative of the genus has heretofore been found on Long Island.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

DAMMARA MICROLEPIS Heer.

(PLATE 71, FIGS. 9, 10.)

Dammara microlepis Heer, Fl. Foss. Arct. 6^2: 55. *pl. 40, f. 5*.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

FRENELOPSIS HOHENEGGERI (Ettingsh.) Schenk?

(PLATE 72, FIG. 1.)

Frenelopsis Hoheneggeri Schenk (Foss. Pfl. Wernsdorfer

Schichten Nordkarpathen), Palaeontog. 19[1]: 13. *pl. 4, f. 5–7; pl. 5, f. 1, 2; pl. 6, f. 1–6; pl. 7, f. 1.*

Thuites Hoheneggeri Ettingsh. (Beitr. Fl. Waeldenperiode). Abh. K.K. Geol. Reichsanstalt, 1[3]: No. 2. 26. *pl. 1, f. 6, 7.*

It would perhaps be safer to merely designate this specimen as a branch of some coniferous tree, but it certainly resembles this species as figured by Heer, from Greenland (Fl. Foss. Arct. 3 (Kreide-Fl.): *pl. 18, f. 6*) and by Newberry from New Jersey, (Fl. Amboy Clays, *l. c. pl. 12, f. 4, 5*) so closely, that at least a provisional reference seems to be justified. I am inclined to think, however, that, so far as Newberry's figures are concerned, these represent nothing more than defoliated and partly decorticated branches of *Widdringtonites Reichii* (Ettingsh.) Heer, as may be seen by comparing these figures with those of the latter species as depicted in the Flora of the Amboy Clays on *pl. 8, f. 3* and *4*.

Formation and locality: Cretaceous shale; Center Island, Oyster Bay, Long Island, N. Y.

Poacites sp.

(Plate 73, fig. 1.)

Fragments of linear, parallel-veined leaves, similar to the one here figured, occur frequently in the Cretaceous material of Long Island and specimens may be found figured under the above generic name in a previous paper (Bull. Torrey Club, 21: 63. *pl. 180, f. 2, 12*).

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

Quercus Morrisoniana Lesq.

(Plate 73, fig. 5.)

Quercus Morrisoniana Lesq. Cret. and Tert. Fl. 40. *pl. 17, f. 1, 2.*

This is the first record of the occurrence of this species on Long Island, although it has been found in the Cretaceous of Cliffwood, N. J.

Formation and locality: Cretaceous shale; Center Island, Oyster Bay, Long Island, N. Y.

Ficus sapindifolia sp. nov.

(Plate 78, fig. 5.)

Leaf about 11.5 cm. long, entire, unsymmetrical, curved, lanceolate-falcate in outline, narrowed rather abruptly and uniformly

from above the middle upward, curving gradually to the base on the convex side and more or less abruptly rounded on the other; midrib curved; secondaries numerous, diverging at an acute angle from the midrib and extending, subparallel and almost straight, nearly to the margin, where they curve upward and anastomose.

This leaf has some of the characters of *F. magnoliaefolia* Lesq. (Cret. & Tert. Fl. 47. *pl. 17, f. 5, 6*) but it is more unsymmetrical and suggests, in its outline, leaves of *Sapindus*. It also has many points of resemblance to *F. Beckwithii* Lesq. (Cret. & Tert. Fl. 46. *pl. 16, f. 5; pl. 17, f. 3, 4*) but is broader and with a less robust midrib. Collected by Mr. A. E. Anderson.

Formation and locality: Cretaceous shale; Manhassett Neck, Long Island, N. Y.

Nelumbo Kempii (Hollick)

(PLATE 74, FIGS. 1, 2; 75; 76; 77, FIG. 1.)

Serenopsis Kempii Hollick, Bull. Torrey Club, **20**: 168. *pl. 149; ibid.* 334. *pl. 166.* 1893.

The first specimens of this species were found about eleven years ago. They were fragmentary and in their general appearance suggested relationship with the palms, which was indicated in the generic name adopted. Specimens recently collected however have demonstrated that this original conclusion was erroneous and that all should be included under the genus *Nelumbo*. They vary considerably in size, but all undoubtedly belong to the same species and with the material now in our possession the following amended description seems advisable:

Leaves peltate, varying in diameter from 40 cm. or more to 15 cm. or less; nervation radiate; primary nerves numerous, prominent, flexuous or straight, often conspicuously ridged or keeled, especially towards the center of the leaf, forked towards the margin and connected by fine, more or less obscure cross nervation.

This species, relatively abundant on Long Island, has not been found on Staten Island or in New Jersey and its identification as a species of *Nelumbo* was an interesting surprise. The only other fossil representative of the genus from eastern North America is the diminutive *N. primaeva* Berry (Bull. N. Y. Bot. Gard. **3**: 75. *pl. 43, f. 1.* 1903), from the Cretaceous of Cliffwood, N. J., reproduced on PLATE 77, FIG. 3. Heer however has described and figured a species, under the name *Nelumbium arcticum* (Fl. Foss. Arct. **6**[2]: 92. *pl. 40, f. 6*), from the lower Atane beds of Green-

land, which, although very fragmentary, may be seen to have a striking resemblance to ours. For purposes of comparison this figure is reproduced on PLATE 77, FIG. 2. These beds belong to practically the same geologic horizon as our Long Island Cretaceous and a number of species are known to be common to both, so that there is a strong probability that Heer's *Nelumbium arcticum* may be identical with our *Nelumbo Kempii*. In any event we have in these remains the oldest known record of the genus.

Formation and locality: Cretaceous shale. PLATE 74, FIG. 2, from Manhassett Neck, Long Island, N. Y., collected by Mr. A. E. Anderson; all others from Glen Cove, Long Island, N. Y.

MAGNOLIA TENUIFOLIA Lesq.?

(PLATE 73, FIG. 2.)

Magnolia tenuifolia Lesq. Am. Jour. Sci. **46**: 100. 1868; Cret. Fl. 92. *pl. 21*, *f. 1*.

On account of the fragmentary nature of this specimen its reference to the above species is made provisional only. If the midrib were more robust it would compare quite satisfactorily with *Magnolia amplifolia* Heer (Kreide-Fl. Moletein, 21. *pl. 8*, *f. 1*, *2*; *pl. 9*, *f.* 1), as there is a slight indication of inequality between the two sides of our leaf. It is apparently identical with the fragment referred to *M. tenuifolia* by Berry, from the Cretaceous of Cliffwood, N. J. (Bull. N. Y. Bot. Gard. **3**: 77. *pl. 47*, *f. 10*) and it also has a strong resemblance to *M. pseudo-acuminata* Lesq. (Fl. Dak. Gr. Monog. U. S. Geol. Surv. **17**: 199. *pl. 24*, *f. 2*), from Kansas.

Formation and locality: Cretaceous shale; Sea Cliff, Long Island, N. Y.

MAGNOLIA CAPELLINI Heer.

(PLATE 78, FIG. 3.)

Magnolia Capellini Heer, Phyl. Crét. Néb. 21. *pl. 3*, *f. 5*, *6*.

This is one of the most clearly defined and abundantly represented species in the Cretaceous of Long Island, and a fine specimen from Glen Cove was one of the first found at that locality (Trans. N. Y. Acad. Sci. **12**: 234. *pl. 6*, *f. 6*. 1893), but it does not seem to be common elsewhere in the region. A fragment from Cliffwood, N. J., has been referred to this species by Berry (Bull. Torrey Club, **31**: 76. *pl. 3*, *f. 3*. 1904) and Lesquereux identified the species in a collection from Sayreville, N. J. (Geol.

Surv. N. J., Rept. on Clay Deposits, 28–29. 1878), but as he says : "these specimens are few and poor, and therefore the determinations are not positively ascertained," the proofs of its occurrence in New Jersey are not satisfactory.

Formation and locality: Cretaceous shale; Center Island, Oyster Bay, Long Island, N. Y.

Sassafras hastatum Newb. ?

(Plate 79, fig. 4.)

Sassafras hastatum Newb. (Fl. Amboy Clays) Monog. U. S. Geol. Surv. **26**: 88. *pl. 27, f. 4–6; pl. 28, f. 1, 2; pl. 40, f. 4.*

This specimen might be referred to any one of several species of *Aralia* or *Sassafras* from the Cretaceous of this region, but the remains are too fragmentary for any but provisional determination. Comparisons may be made with *Aralia palmata* Newb. (Fl. Amboy Clays, *l. c.* 117. *pl. 39, f. 6, 7; pl. 40, f. 3*) and *A. Grönlandica* Heer, as figured by Newberry (Fl. Amboy Clays, *l. c. pl. 28, f. 4*), to both of which species Berry has referred fragmentary specimens from the Cretaceous of Cliffwood, N. J. (Bull. N. Y. Bot. Gard. 3: *pl. 44; pl. 45, f. 4.* 1903).

I am inclined, however, to regard our specimen as referable to the species described under the name *Sassafras hastatum*, as above quoted; but, without the base of the leaf, any definite conclusion is impossible.

Formation and locality: Cretaceous shale, Glen Cove, Long Island, N. Y.

Phaseolites Manhassettensis sp. nov.

(Plate 78, figs. 1, 2.)

Leaf about 7.5 cm. long, including a petiole of 6 mm., entire, inequilateral, slightly falcate, one side abruptly rounded and broadest at the base and curving to the apex, the other broadest at about the middle and tapering unequally to the base and apex; midrib slightly flexuous and curved towards the narrow or concave side of the leaf; secondaries irregularly disposed, diverging from the midrib at varying, acute angles, subparallel, curved upwards and camptodrome near the margin.

Our specimens are imperfect at the apex, where they are bent or folded under, giving the appearance of emargination, as indicated in the figures, but with this exception they have such a close resemblance to *Phaseolites formus* Lesq. (Fl. Dak. Gr., Monog. U. S.

Geol. Surv. **17**: 147. *pl. 55, f. 5, 6, 12*) as to indicate at least generic relationship.

I am also inclined to think that the leaves originally referred by me to *Dalbergia Rinkiana* Heer, from Brooklyn and Lloyd's Neck (Trans. N. Y. Acad. Sci. **12**: 236. *pl. 6, f. 4, 5.* 1893) may properly be included in our new species.

Collected by Mr. A. E. Anderson.

Formation and locality: Cretaceous shale; Manhassett Neck, Long Island, N. Y.

Sapindus imperfectus sp. nov.

(PLATE 78, FIG. 4.)

Leaf about 9.5 cm. long by 3.5 cm. maximum width, entire, lanceolate-falcate in outline, inequilateral, broadest considerably below the middle, each side tapering to the apex and unequally rounded to the base; midrib curved; secondaries subparallel, diverging from the midrib at angles of about 45°, those on the curved side somewhat more acutely, especially the upper ones.

I am of the opinion that this species should also include the leaf originally referred by me to *Sapindus Morrisoni* Lesq., from Glen Cove (Trans. N. Y. Acad. Sci. **12** : 235. *pl. 6, f. 3.* 1893).

Collected by Mr. A. E. Anderson.

Formation and locality: Cretaceous shale; Manhassett Neck, Long Island, N. Y.

ZIZYPHUS ELEGANS Hollick

(PLATE 73, FIG. 4.)

Zizyphus elegans Hollick, Bull. Torrey Club, **21**: 58. *pl. 177, f. 9, 10.* 1894.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

ARALIA CORIACEA Vel.

(PLATE 73, FIG. 3.)

Aralia coriacea Vel. Fl. Böhm. Kreideform. 3: 11 [58]. *pl. 1* [*16*], *f. 1–9; pl. 2* [*17*], *f. 2.*

This leaf is well defined and resembles so closely the shorter forms of the species, as depicted in *f. 1* above quoted, that there would seem to be little doubt of the specific identity of the two specimens.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

ANDROMEDA FLEXUOSA Newb.

(PLATE 79, FIG. 2.)

Andromeda flexuosa Newb. (Fl. Amboy Clays) Monog. U. S. Geol. Surv. **26**: 121. *pl. 34, f. 1–5.*

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

ANDROMEDA LATIFOLIA Newb.

(PLATE 79, FIG. 3.)

Andromeda latifolia Newb. (Fl. Amboy Clays) Monog. U. S. Geol. Surv. 26: 120. *pl. 33, f. 6–10; pl. 34, f. 6–11; pl. 36, f. 10.*

The variety of forms included under this species affords opportunity for a wide range of reference. Our specimen may be most satisfactorily compared with Newberry's *pl. 33, f. 8*, above quoted.

Formation and locality: Cretaceous shale; Oak Neck, Long Island, N. Y.

PREMNOPHYLLUM TRIGONUM Vel.

(PLATE 79, FIG. 1.)

Premnophyllum trigonum Vel. Fl. Böhm. Kreideform. 3: 4 [51]. *pl. 3* [*18*], *f. 2.*

Although there can be but little doubt that our specimen is referable to this species the indicated relationship with the genus *Premna* must be considered as entirely problematical, especially in the light of our new material, which apparently represents two leaflets of a compound, pinnate leaf. Velenovsky subsequently changed the name to *Cissophyllum exulum* (Květ. Česk. Cenomanu, 24. *pl. 6, f. 4, 5*), concluding that it was more likely related to the genus *Cissus*. Until, however, we are in a position to determine the true botanical affinities with reasonable certainty it would hardly appear advisable to make any change in the original name.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

Tricalycites major sp. nov.

(PLATE 72, FIGS. 3–7.)

Organism normally consisting of three entire, oblong-spatulate wings or appendages, tri-palmately arranged and attached to a common nucleus by their bases, finely and closely striated longitudinally, middle one usually the largest, about 4 cm. long by 1.3 cm. broad.

These well-defined organisms are evidently generically identical

with those described by Newberry under the name *Tricalycites papyraceus* (Fl. Amboy Clays, *l. c.* 132. *pl. 46, f. 30–38*), and they merely differ in their larger size. In some specimens, as indicated in FIGS. 5 and 6, the appendages appear as if confluent at their bases, which is probably due to overlapping, and doubtless these specimens, if perfect, would present the appearance of three-lobed samarae.

It is with some hesitation that I have included FIG. 7 in this species, for the reason that only two appendages are present, which are shorter and more coarsely striated than in the other specimens, but it may perhaps be merely an abnormal or defectively preserved one. It is almost certain that the specimen from the same locality previously described and figured by me as "apparently a winged seed or samara" (Bull. Torrey Club, **21**: *62. pl. 180, f. 1.* 1894), should be regarded as one of the detached parts of this species.

Formation and locality: Cretaceous shale; Glen Cove, Long Island, N. Y.

Calycites alatus sp. nov.

(PLATE 72, FIG. 8.)

Organism triangular in outline, consisting of a top-shaped nucleus, to which are attached two entire, broadly spatulate, longitudinally striated, wing-like appendages, each about 6 mm. long by 5 mm. maximum width.

This little organism may perhaps belong in the genus last mentioned, and it was in fact originally referred by me to *Tricalycites papyraceus* Newb. when first discovered (Trans. N. Y. Acad. Sci. **15**: 6. 1895), but I am now inclined to think that this reference was not warranted and that it should have a distinctive name.

Formation and locality: Cretaceous shale; Montauk Point, Long Island, N. Y.

Explanation of Plates 70–79

PLATE 70

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Nelumbo Kempii (Hollick) 412

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Nelumbo Kempii (Hollick) 412

PLATE 77

FIG. 1. *Nelumbo Kempii* (Hollick) 412
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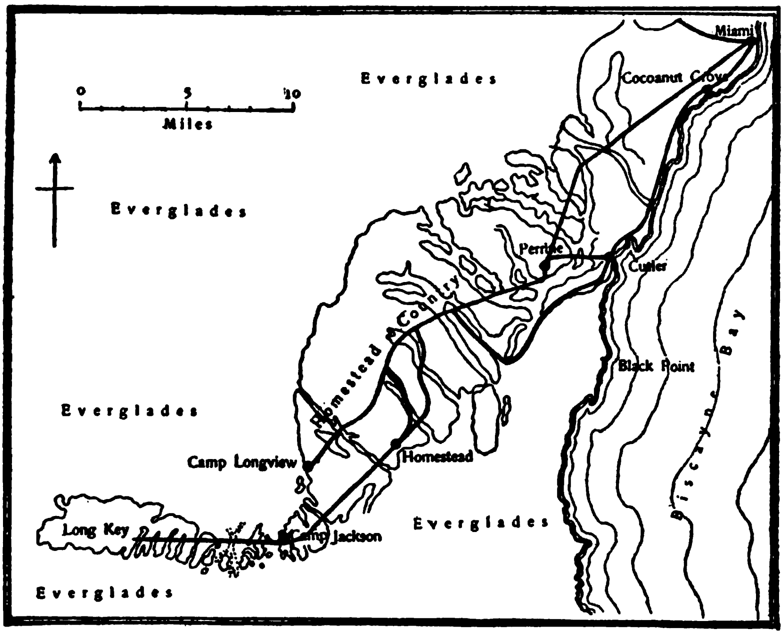
Additions to the Flora of Subtropical Florida.

By John K. Small.

The additions to the flora of the North American mainland enumerated in this paper were secured for the most part on three trips of exploration to south Florida, one in the fall of 1903, the other two in the spring of 1904. With the exception of a single species from Elliott's Key, and three species from the vicinity of Fort Lauderdale, the plants below mentioned came from the ridge



of coral-sand rock which extends from Miami to Camp Longview and Camp Jackson. The positions of the localities mentioned under the several species may be seen on the accompanying map, where the heavy lines indicate the main routes of exploration.

General reports on the expeditions to the portion of south Florida under consideration have been published in the *Journal of the New York Botanical Garden*, nos. 26, 51, 55 and 56.*

*Jour. N. Y. Bot. Gard. 3: 29–35. F 1902; 5: 49–53. Mr 1904; 5: 129–136. Jl 1904; 5: 157–164. Au 1904.

The type-specimens of the species described in this paper, and a complete set of the specimens secured on the several expeditions, have been placed in the herbarium of the New York Botanical Garden.

CYMODOCEA MANATORUM Aschers.

This rare aquatic plant, formerly known mainly from the West Indies, was collected along the shore near Cape Florida below Miami, by Dr. M. A. Howe, March 29, 1904 (no. 315).

Stenophyllus Carteri Britton, sp. nov.

Annual, bright green: leaves erect; blades setaceous, ciliate; sheaths scarious: scapes tufted, 0.5 dm. tall, very slender, scabrous near the top: bracts of the involucre mostly 3, one of them longer than the inflorescence, blades ciliate-serrulate: spikelets numerous, in a terminal compound umbel, mainly ovoid, few-flowered; scales brown, acute, ciliate-scabrous along the margins: achenes obovoid, about 0.5 mm. long, depressed at the apex, minutely papillose, the tubercle very small.

A characteristic species, related to *Stenophyllus coarctatus* (Ell.) Britton; differing in the ciliate leaf-blades, the ovoid spikelets and the small achene. The type-specimens were collected in the pinelands between Cocoanut Grove and Cutler in November, 1903 (*Small & Carter*, no. 1263).

TILLANDSIA SUBLAXA Baker

Previously known from several islands of the West Indies, this species was found in a large hammock east of Fort Lauderdale by Mr. J. J. Carter and the writer, November 19–25, 1903 (no. 968).

The most closely related species occurring on the North American mainland is *Tillandsia Valenzuelana*.

CATOPSIS NUTANS (Sw.) Griseb.

Although this species has already been accredited to the flora of the continent, the *Catopsis* formerly known to occur here was *C. Berteroniana* and not *C. nutans*. *Catopsis nutans* was first collected in Florida by Mr. J. J. Carter and the writer in hammocks along the homestead trail near Camp Longview, Dade Co., in November, 1903 (no. 972). In May, 1904, the species was found on the eastern end of Long Key (mainland), by Mr. Wilson and the writer, as well as in other hammocks in adjacent Dade Co. (no. 1911).

GUZMANIA MONOSTACHYA (L.) Rusby

This plant, heretofore only known from tropical America, was recently detected in hammocks in the homestead country south of Miami. During an excursion towards Camp Longview, November 9–12, 1903, Mr. J. J. Carter and the writer collected specimens in hammocks along the homestead trail (no. 971). In March, 1904, Dr. Britton visited this region and secured fruiting specimens similar to those collected the previous fall (no. 257). Last May on excursions to Long Key (mainland) and Camp Longview, Mr. Wilson and the writer found the species at many other stations, the plants being in full bloom (no. 1997).

This bromeliad is by far the most showy member of the group of air-plants that occurs in the United States. The effect of the conspicuous inflorescence is augmented by the great profusion in which the plants occur and by the not uncommon variegation of the long leaves.

ALETRIS BRACTEATA Northrop

This species, recently described from specimens collected several years ago in the Bahamas, grows quite abundantly on the prairies or extensions of the everglades southwest of Cutler. It was first collected in Florida by Mr. J. J. Carter and the writer on an excursion towards Camp Longview, November 9–12, 1903 (no. 1080), and was later found in great quantities in the same region and as far southwest as Long Key (mainland), by Mr. Wilson and the writer in May, 1904 (nos. 1718 and 1885).

Limodorum pinetorum sp. nov.

Perennial by thick corm-like rootstocks: leaves few, the outer one or two reduced to sheathing scales, the inner erect; blades narrowly linear, 0.5–1.5 dm. long: scape 1–2.5 dm. tall: perianth deep rose-colored: median sepal oblong-lanceolate, 12–14 mm. long, acute; lateral sepals oblong-ovate, 10.5–11.5 mm. long, acutish: petals 11–12 mm. long, the blade oblong or nearly so: lip 10–11 mm. long, middle lobe cuneate, 6–8 mm. wide, crested in the middle, nearly truncate at the apex and mucronate: column-wings half-orbicular.

Related to *Limodorum multiflorum*, which has broadly ovate lateral sepals, a proportionately much wider lip with the crest extending to the margins, and rhombic column-wings. The type-specimens were collected in the pinelands along the homestead trail, between Cutler and Camp Longview in May, 1904 (*Small & Wilson*, no. 1676).

Quercus Rolfsii sp. nov.

A rigid shrub, or a small tree becoming 7 m. tall, with ascending branches, the twigs light brown: leaf-blades cuneate in outline, leathery, 2.5–6 cm. long, mostly 3-lobed at the apex, or sometimes 5-lobed, bright green, glabrous and finely reticulated above, pale and thinly stellate-pubescent beneath, the lobes mostly blunt and not bristle-tipped: acorns usually in pairs at the ends of short peduncles; cup hemispheric above a stout base, 1.5–1.8 cm. high, about 1.5 cm. broad, the scales appressed, densely whitish pubescent except at the tip; nuts oblong, or slightly broadest below the middle, 2–2.5 cm. long, about ½ included in the cup.

A very characteristic species, especially on account of the deep and peculiarly shaped cup of the acorn. In the arrangement of the oaks adopted in my Flora of the Southeastern United States this plant would come next to *Quercus undulata*, from which it differs in the blunt lobes or teeth of the leaf-blades and the deep cup of the acorn. The type-specimens were collected in the pinelands near Ft. Lauderdale, Florida, by Prof. P. H. Rolfs, Mr. J. J. Carter and the writer in November, 1903 (no. 1044).

Quercus succulenta sp. nov.

A shrub, mostly about 1 m. tall, with soft spreading branches, the twigs gray-black: leaf-blades broadly linear to cuneate, fleshy-leathery, 2–4.5 cm. long, entire or with 3–5 slightly spinescent lobe-like teeth, smooth and glabrous above, tomentulose beneath: pistillate flowers in elongated peduncled spikes: acorns peduncled; cup saucer-shaped, 3–4 mm. high, 5–6 mm. broad, the upper scales obtuse; nut oblong-conic, 1–1.3 cm. long, only the very base included in the cup.

As in the case of *Quercus Rolfsii*, this plant is a live-oak. It is remarkable on account of its fleshy branches and leaves, and the very small, shallow and thin cup of the acorn. In these particulars it differs from all other members of the group to which it belongs. The type-specimens were collected near Ft. Lauderdale, Florida, by Mr. J. J. Carter and the writer, in November, 1903 (no. 1044).

Phytolacca rigida sp. nov.

An herb 1–3 m. tall, or sometimes a tree becoming 6 or 7 m. tall, the stem and branches mostly greenish purple: leaf-blades lanceolate or oblong-lanceolate, 7–34 cm. long, deep green, acuminate at the apex, narrowed into petiole-like bases: panicles permanently erect: pedicels 2–5 mm. long, stout and during anthesis slightly surpassing the subtending bracts, not longer than the diameter of

the perianth: sepals ovate or oblong-ovate, 3 mm. long, apiculate, and more or less erose-toothed at the apex: filaments about 2 mm. long: berries spheroidal, 10–12 mm. broad, dark purple, the juice crimson: seeds 3 mm. long.

A species with the habit of *Phytolacca decandra*, from which it differs in the relatively longer or narrower leaf-blades, the short pedicels which are much shorter than the diameter of the berries, and the permanently erect panicles. The type-specimens were collected in hammocks at Miami, Florida, in May, 1904 (*Small & Wilson*, no. 1893). Other collections are as follows:

Ft. Myers, *Hitchcock*, no. 301.

Braidentown, *Tracy*, no. 7531.

Miami, *Small & Carter*, no. 664: *Britton*, no. 467.

St. Augustine, *Small & Wilson*, no. 2010.

Dalbergia Amerimnum Benth.

Heretofore a single species of *Dalbergia* has been known to occur in Florida, namely *D. Ecastophyllum* (L.) Taub. While collecting near the southern end of Elliott's Key on April 1, 1904, Dr. Britton discovered *Dalbergia Amerimnum* Benth. (no. 375).

Aeschynomene pratensis sp. nov.

Annual or perhaps perennial, woody below: stem 1–2 m. tall, widely and irregularly branched: leaves few and scattered, 4–5 cm. long; leaflets mainly 15–25, the blades narrowly oblong, 5–6 mm. long, obtuse, short-petioled: flowers few, slender-pedicelled: calyx 5–6 mm. long, glabrous, the lips nearly equal: corolla mainly yellow; standard with a suborbicular blade 10 mm. in diameter, and a short claw; wing-petals 8 mm. long, with a prominent auricle at the base of the blade; keel-petals more strongly curved than the wing-petals with a more slender base and a smaller auricle: pods mainly 3–6 cm. long, curved, stipe 10–15 mm. long: joints typically 7 mm. long, more strongly curved above than below; the sides strongly rugose at maturity: seeds 5 mm. long.

Related to *Aeschynomene sensitiva* Sw. of the West Indies, but readily distinguished by the glabrous calyx, the petals, and the pods, whose joints are of a very different shape from those of *A. sensitiva* and have coarsely rugose sides. The type-specimens were collected in the everglades near the Slough between Camp Jackson and Long Key (mainland) in May, 1904 (*Small & Wilson*, no. 1960). Similar specimens with immature fruit were collected in the everglades near Paradise Key by Dr. Britton, in March, 1904 (no. 233).

Alvaradoa amorphoides Liebm.

This tropical American plant was found in Caldwell's Hammock, Dade Co., by Dr. Britton and Prof. Rolfs, March 26, 1904 (no. 260). During May of the same year Mr. Wilson and the writer found it in neighboring hammocks (no. 1708) and on Long Key (mainland) (no. 1872).

Linum Carteri sp. nov.

Annual, bright green: stem erect, 1–3 dm. tall, simple or somewhat corymbosely branched, striate, the ridges scabrous: leaves alternate, approximate, but not very numerous, at the base of the stem, rather distant above; blades narrowly linear or linear-subulate, entire, minutely spine-tipped, sessile: bracts glandular-serrulate: flowers short-pedicelled: sepals lanceolate or ovate-lanceolate, acuminate, 4.5–5 mm. long, rathei evenly glandular-serrulate, but the inner rather more finely and regularly so than the outer: corolla yellow; petals broadly cuneate, 10–12 mm. long, mostly emarginate: filaments glabrous: styles united to near the tips, glabrous: capsule ovoid, 4 mm. long, blunt, surpassed by the sepals.

A very showy species related to *Linum rigidum* Pursh, peculiar in being the only representative of the group to which that species belongs, known east of the Mississippi River. It may be separated from *Linum rigidum* by the smaller sepals with finer and less prominently glandular teeth and the relatively broader and shorter capsule. The type-specimens were collected in the pinelands between Cocoanut Grove and Cutler in November, 1903 (*Small & Carter*, no. 758). In March, 1904, Dr. Britton found specimens in the homestead country beyond Cutler (no. 170), while in May, 1904, Mr. Wilson and the writer discovered it in great abundance between the last named locality and Camp Longview (no. 1721).

Linum Curtissii sp. nov.

Annual, glabrous: stems erect, 2–6.5 dm. tall, corymbosely branched above, or sometimes simple, slightly striate in age: leaves mainly alternate, ascending or erect: blades oblong-spatulate or oblanceolate on the lower part of the stem to linear or nearly so above, 0.5–1.5 mm. long, acute or acutish or somewhat acuminate, entire: flowers short-pedicelled: sepals 2–2.8 mm. long, ovate, sometimes narrowly so, somewhat acuminate, the outer with few irregularly placed glandular teeth, the inner with more numerous and more regularly placed teeth: corolla yellow, mostly about 8 mm. broad: capsules spheroidal, about 2.5 mm. high, surpassed by the sepals.

A species with the habit of *Linum medium* (Planch.) Britton, with which it agrees in many characters. It may readily be distinguished from *L. medium* by the ovate and toothed outer sepals; these in *L. medium* being lanceolate and entire. The type-specimens were collected near Nassau, N. P., Bahamas, by Mr. A. H. Curtiss, May, 1903 (no. 207). During the fall of 1903, the species was discovered in the everglades between Cocoanut Grove and Cutler, Florida, by Mr. J. J. Carter and the writer (no. 565). In March, 1904, Dr. Britton collected specimens of this species in the homestead country below Cutler (no. 180).

Polygala corallicola sp. nov.

Polygala grandiflora leptophylla Chodat, Mem. Soc. Phys. et Hist. Nat. Genev. **31**: 57. 1893; not *P. leptophylla* Burch. 1822.

Perennial, slender: stem simple or sparingly branched at the base and above, 2–4.5 dm. tall, finely appressed-pubescent: leaves few; blades linear, typically narrowly so, or filiform-linear, 1–5 cm. long, acute, glabrous or essentially so at least above the base: racemes loosely flowered, 1-sided: pedicels 1.5–2 mm. long: flowers purplish or greenish-purple: outer sepals nearly 1.5 mm. long, sparingly glandular-ciliate: wings 3.5–4 mm. long, the blade suborbicular or orbicular-obovate: keel 4–4.5 mm. long, the claw pubescent at the base: lateral petals with blades nearly 1.5 mm. wide: stamens mostly 8: capsules oblong, 3–3.5 mm. long, notched at the apex: seeds about 2.5 mm. long, the caruncle helmet-like.

Related to *Polygala grandiflora* Walt., but easily distinguished by the very narrow leaves, the smaller flowers with the purplish wings only 3.5–4 mm. long at maturity. The following specimens collected in Florida belong here:

Miami, *Small & Nash*, October 27–November 13, 1901; *Britton*, no. 25.

Between Cocoanut Grove and Cutler, *Small & Carter*, no. 764.

Black Point, *Small & Carter*, November 13, 1903.

Long Prairie, Dade Co., *Britton*, no. 190.

Between Homestead and Camp Jackson, *Small & Wilson*, no. 1666.

Camp Longview, *Small & Wilson*, no. 1726.

No Name Key, *Pollard, Collins & Morris*, no. 115.

Polygala Carteri sp. nov.

Biennial, dark green, glabrous: stem erect. 1–5.5 dm. tall, simple or corymbosely branched above, rarely, if ever, tufted: leaves few, alternate and remote above the basal whorl; blades spatulate, sometimes broadly so at the base of the stem, narrowly spatulate to linear-oblong or nearly linear above, 1–3.5 cm. long, or shorter near the top of the stem, obtuse or acutish, entire, sessile: racemes ovoid to cylindric, mostly about 1 cm. long during early anthesis, often becoming 2.5–3.5 cm. long: bracts lanceolate, acuminate, 1.5–2 mm. long: pedicels barely 1 mm. long: sepals decurrent on the pedicel, the upper sepal lanceolate, acuminate: wings oblong, scarcely twice as long as the sepals, about 3 mm. long, erose near the mucronate-acuminate apex: keel terminating in several, often clavate or forked processes: lateral petals nearly oblong, notched near the apex: style enlarged near the stigma, the incurved appendage dilated at the apex: capsule nearly 1 mm. broad: seed ovoid, pubescent, 0.7 mm. long, the caruncle minute or obsolete.

A species related to *Polygala Baldwinii;* but distinguished by its elongated racemes and cuspidate wings. The type-specimens were collected in the pinelands between Cutler and Black Point, November, 1903 (*Small & Carter*, no. 813). The following specimens also belong to this species:

Camp Jackson, *Rolfs*, no. 282; *Small & Wilson*, no. 1921.

Between Homestead and Camp Jackson, *Small & Wilson*, no. 1674.

Camp Longview, *Small & Wilson*, no. 1916.

Cocoanut Grove, *Small & Wilson*, no. 1926.

Polygala arenicola sp. nov.

Biennial, with a short simple or branching caudex, the short branches often densely tufted, and partly buried in the sand: leaves approximate or crowded, fleshy; blades oblanceolate or linear-oblanceolate, 1.5–5 cm. long, mostly acute: racemes sessile or nearly so, 1–2.5 cm. long, cylindric: rachis winged: bracts linear-lanceolate, acuminate, ultimately deciduous: flowers green and drying green: sepals decurrent on the pedicel: wings lanceolate, long-acuminate, 5–6 mm. long, remotely ciliatc-serrulate, the sepals shorter and relatively broader: keel terminating in 2 blunt processes: lateral petals rounded and undulate at the apex: stamens 8: style prolonged into an incurved tufted appendage: seed nearly 2 mm. long, the 2 reflexed lobes of the caruncle barely as long as the seed-body.

This dwarf species is most closely related to *Polygala nana* (Michx.) DC. The plants are commonly smaller than those of

P. nana and may be distinguished by the narrow leaf-blades, as contrasted with the more or less dilated spatulate leaf-blades of that species, and by the smaller flowers with less attenuate tips of the sepals. The type-specimens were collected in pinelands between Cocoanut Grove and Cutler in November, 1903 (*Small & Carter*, no. 1276).

Specimens were also collected by Dr. Britton, at Perrine below Cutler, in March, 1904 (no. 149).

Polygala flagellaris sp. nov.

Perennial, glabrous, deep green: stems several or many from a short caudex, radially spreading, decumbent, procumbent or declining, 1.5–6 dm. long, slender, irregularly branched: leaves fleshy, numerous, commonly very numerous, whorled on the lower part of the stems, the whorl commonly in 5's, or alternate above; blades spatulate, the lower ones often broadly so, the upper narrowly so, or linear-spatulate, 4–11 mm. long, slender-tipped, sessile: racemes narrow, elongated and interrupted in age: bracts lanceolate or linear-lanceolate, 1.5–2 mm. long, deciduous: pedicels 0.5–1.5 mm. long: flowers greenish, or pink-tinged: sepals not decurrent on the pedicel, pale-edged, wings oval, usually acutish, 2.5–3 mm. long, entire: keel terminating in several slender processes: lateral petals broadly ovate, about 2 mm. long, obtuse: stamens 8: style with a terminal incurved appendage and 2 auricles at the base of the stigma: capsule oblong, 2.5 mm. long: seed about 2 mm. long, hairy, the reflexed caruncle-lobe barely one half as long as the seed-body.

A characteristic species related to *Polygala Boykinii* Nutt. but different in habit and typical condition with very numerous leaves. The flowers are commonly more numerous and smaller than in *P. Boykinii*, while the wings are obovate instead of ovate. The capsules are relatively longer and narrower than in *P. Boykinii* and smaller. The type-specimens were collected in the pinelands, along the homestead trail near Camp Longview, in November, 1903 (*Small & Carter*, no. 1078). Other specimens belonging to this species are as follows:

Black Point, *Small & Carter*, no. 829.
Gossmans, *Britton*, no. 169.
Long Key (mainland), *Small & Wilson*, no. 1806.

PEDILANTHUS TITHYMALOIDES (L.) Poit.

This succulent vine, rather common in the West Indies, has become thoroughly established in Brickell Hammock south of Miami.

Specimens were collected by Mr. Percy Wilson and the writer in May, 1904 (no. 1912).

Phyllanthus saxicola sp. nov.

Annual, glabrous: stem 0.5–3.5 dm. tall, simple or irregularly branched: leaves relatively numerous, erect or nearly so; blades leathery cuneate, 5–9 mm. long, obtuse, entire, bright green, short-petioled: flowers very short-pedicelled: calyx of the pistillate flowers less than 2 mm. wide at maturity; lobes obovate: disk rather angular: capsule spheroidal, barely 2 mm. wide: seeds less than 1 mm. long, nearly as wide as long, papillose.

A species related to *Phyllanthus Carolinensis*, but smaller throughout. It differs from *P. Carolinensis* in the small leathery approximate leaves, the smaller calyx with broader lobes, and the smaller seeds. The type-specimens were collected on projecting coral-sand rock in the everglades between Cocoanut Grove and Cutler, in November, 1903 (*Small & Carter*, no. 775).

Croton arenicola sp. nov.

Annual, sometimes partially woody at base: stem 1.5–4.5 dm. tall, simple to the inflorescence or branched at the base, the branches like the stem stellate-glandular, forking above: leaf-blades thickish, ovate, varying to oblong-ovate, those of the upper leaves typically ovate, 1–3 cm. long, coarsely crenate or sometimes crenate-dentate with few scattered stellate hairs at maturity: petioles $\frac{1}{4}$–$\frac{1}{8}$ as long as the blades, pubescent like the branches: flowers monoecious: the staminate with lanceolate bracts 1–2 mm. long, sepals oval to oblong, about 2 mm. long: petals oblong to oblanceolate, white, somewhat larger than the sepals: stamens 9–12, filaments pilose at the base: pistillate flowers solitary or clustered below the staminate: sepals spatulate, accrescent: petals mainly obsolete: capsules globose-oval, 4.5–5 mm. long: seeds 3–3.5 mm. long, punctate.

Plants belonging to this species have heretofore been referred to *Croton betulinus* Vahl; the most closely related *Croton* occurring in North America is *C. glandulosus septentrionalis*, from which this species may be separated by the typically ovate and crenate blades of the upper leaves. The type-specimens were collected in pinelands between Cutler and Black Point, in November, 1903 (*Small & Carter*, no. 822). Other specimens belonging to this are:

Cape Florida, *Henderson*, early last century; *Britton*, no. 312.
Miami, *Curtiss*, no. 5840.
Between Cocoanut Grove and Cutler, *Small & Carter*, no. 549.

Bull Key, opposite Lemon City, *Small & Carter*, no. 642.
Along Boca Ratone Lake, *Small & Carter*, no. 1242.

Stillingia tenuis sp. nov.

A shrub 3–12 dm. tall, with slender virgate stems or branches, the stem typically unbranched at the base, the bark ultimately with many transverse cracks: leaves early deciduous from the lower part of the stem and the branches, mostly approximate at the tips of the branches; blades linear or nearly so, commonly narrowly linear, 2–10.5 cm. long, finely, closely and shallowly toothed: staminate portion of the spike slender, 3–5 cm. long, mainly red, the glands larger than the bracts: calyx about 1 mm. long, shallowly lobed: gynophore about 6 mm. wide: capsule depressed-globose, about 7 mm. in diameter: seeds 4–4.5 mm. long, shallowly rugose.

A woody species related to *Stillingia aquatica* Chapm., from which it differs in the more slender habit, narrowly linear leaf-blades, the slender red spikes with small bracts and large glands. The type-specimens were collected in the everglades between Homestead and Camp Jackson, in May, 1904 (*Small & Wilson*, no. 1580). Other specimens referable to this species are as follows:

Between Cutler and Camp Longview, *Small & Carter*, nos. 1095, 1297 and 1440.

Chamaesyce hyssopifolia (L.)

Euphorbia hyssopifolia L. Syst. Ed. 10. 1048. 1759.

This well-marked species, previously collected on some of the West Indian Islands, was found in the pinelands along the homestead trail near Camp Longview by Mr J. J. Carter and the writer, November, 1903 (no. 859).

Chamaesyce pinetorum sp. nov.

Perennial: plants pubescent with pale or white hairs: stem branched at the base, the branches ascending, spreading or prostrate, 8–32 cm. long, forked, more or less retrorse-hirsute: leaf-blades reniform to orbicular or ovate, 2–5 mm. long, more or less revolute, paler and less pubescent beneath than above, entire, short-petioled: involucre broadly campanulate, about 1 mm. high, copiously hirsute; glands relatively large, on broad stalks, elevated above the triangular ciliate involucral lobes, the appendages thick, very narrow or a mere border, pubescent without: capsules depressed, 2 mm. wide, hirsute: seeds ovoid, 1 mm. long, gray-papillose, triangled, obtuse, the faces scarcely wrinkled.

A characteristic species, among North American forms, nearest to *Chamaesyce deltoidea* (Engelm.) Small, but of very different habit and aspect. The hirsute foliage, the ascending branch-ends and the pubescent involucres and capsules readily distinguish this species from *C. deltoidea*. The type-specimens were collected in the pinelands near the homestead trail between Cutler and Camp Longview in November, 1903 (*Small & Carter*, no. 836). Other specimens belong here as follows:

Pinelands near Long Prairie, *Britton*, no. 192 and 193.

Pinelands between Homestead and Camp Jackson, *Small & Wilson*, no. 1665 and 1891.

Pinelands near Camp Longview, *Small & Wilson*, no. 1733.

Ilex Krugiana Loesener

The discovery of this species of *Ilex* in Florida adds another tree to the arboreous flora of North America. The plant was previously known to occur on the Bahamas, in Haiti and San Domingo. Several trees were found in Ross' Hammock near the homestead trail, during an excursion to Camp Longview, May 13–16, 1904, by Mr. Percy Wilson and the writer (no. 1744).

Mangifera Indica L.

The mango has become established in Florida; it now occurs in hammocks both on the mainland and on the keys. Specimens were collected by Mr. J. J. Carter and the writer in hammocks between Cocoanut Grove and Cutler, November, 1903 (no. 1309).

Rhus leucantha Jacq.

Specimens agreeing in all details with the original plate of *R. leucantha* were collected in hammocks near the homestead trail between Cutler and Camp Longview by Mr. J. J. Carter and the writer in November, 1903 (no. 990), and also in hammocks further to the southwest by Mr. Percy Wilson and the writer in May, 1904 (no. 1738). Although the original country where *Rhus leucantha* was found is unknown, taking into consideration the two facts, namely that the plants in question agree perfectly with the original plate and that Jacquin figured many other American plants in the Plantarum Rariorum Horti Caesarei Schoenbrunnensis, we are safe in referring our specimens to this species. In the Prodromus*

* Prodr. 2: 68.

De Candolle reduced this species in an indefinite way to a variety of *R. copallina*, while Gray* developed this idea and assigned it a range from Florida and the West Indies to Texas, but on different materal than that under consideration. The discovery of this species in Florida adds another tree to the flora of the North American mainland.

AYENIA EUPHRASIAEFOLIA Griseb.

This apparently very rare Cuban plant occurs in great abundance all over the coral-sand rock ridge from Miami southward. Specimens were collected at different points from the northern end of the ridge to near Long Key (mainland) (nos. 704, 849, 928 and 886).

AMMANNIA LATIFOLIA L.

This West Indian plant may now be included in the flora of the North American mainland. Specimens were collected several years ago at Key Largo by Mr. Pollard (no. 183), but distributed under a different name. In November, 1903, Mr. J. J. Carter and the writer collected specimens in the everglades between Cutler and Camp Longview (no. 997), and about Boca Ratone Lake, below Delray (no. 1053). In March, 1904, Dr. Britton found plants growing at Cape Florida (no. 314).

TETRAZYGIA BICOLOR (Mill.) Cogn.

The discovery of this plant in Florida adds another tree to the North American mainland flora. This species was first observed in the pinelands about eight miles southwest of Cutler by Mr. J. J. Carter and the writer on a trip to Camp Longview, November 9–12, 1903 (nos. 994 and 1106). Dr. Britton collected specimens in the same region in 1904 (no. 217), while Mr. Wilson and the writer found the species on Long Key (mainland) in May, 1904 (no. 1649), and in hammocks and adjacent pinelands near Camp Longview discovered it growing as a tree sometimes 25 or 30 feet tall (nos. 1696 and 1932).

PASSIFLORA SEXFLORA Juss.

This interesting passion-flower was found in hammocks near the homestead trail between Cutler and Camp Longview by Mr. J. J. Carter and the writer on an excursion to Camp Longview,

* Syn. Fl. N. A. 1^1: 384.

November 9–12, 1903 (no. 791), and in March, 1904, it was collected by Dr. Britton in the same region (no. 264).

Gaura simulans sp. nov.

Biennial, pubescent up to the flowers: stem erect, 1–2 dm. tall, the lower part loosely fine-pubescent, the upper part or slender ascending branches glabrous or nearly so, at least at maturity: leaves copiously pubescent, those of the rosettes and lower part of the stem 8–12 cm. long; blades oblanceolate to narrowly spatulate, pinnatifid: leaves of the upper part of the stem 2–4.5 cm. long; blades lanceolate to linear-lanceolate, sharply toothed or somewhat pinnatifid: hypanthium glabrous: sepals oblong or oblong-lanceolate, 5.5–6 mm. long, obtuse, glabrous: petals pinkish, 4.5–5 mm. long, the blades oval, longer than the claw: style glabrous: fruit 0.5–10 mm. long, glabrous, abruptly narrowed at the base.

A species related to *Gaura angustifolia* Michx. but readily distinguished by the glabrous buds and fruit. The fruit, too, is of a different shape, being relatively much broader and abruptly contracted at the base. The type-specimens were collected in the pinelands between Cocoanut Grove and Cutler, November, 1903 (*Small & Carter*, no. 766). Other specimens belonging here are:

Ft. Myers, *Hitchcock*, no. 123.
Miami, *Small & Nash*, November, 1901.
Virginia Key, *Britton*, no 102.
Between Cocoanut Grove and Cutler, *Small & Wilson*, no. 1591.

Proserpinaca platycarpa sp. nov.

Perennial, glabrous: stem and branches 1–3.5 cm. long, very leafy: leaf-blades uniform or the lower ones with more prominently toothed blades than the upper; blades oblong or elliptic, or slightly broadened upward, 1.5–5.5 cm. long, sharply serrate: sepals deltoid or ovate-deltoid, barely 1 mm. long: hypanthium ridge-winged: fruits 4–5 mm. wide, constricted above the middle, the angles thus abruptly dilated.

Most nearly related to *Proserpinaca palustris* and with the same habit, differing most markedly in the fruit, which is constricted under the apex, thus forming abruptly dilated angles. The type-specimens were collected in the everglades west of Camp Jackson, by Dr. Britton, in March, 1904 (no. 239). Similar specimens are:

Braidentown, *Tracy*, no. 7136.
Ft. Myers, *Hitchcock*, no. 93.
Between Cutler and Camp Longview, *Small & Carter*, no. 1466.
Camp Jackson, *Small & Wilson*, no. 1861.

Adelia pinetorum sp. nov.

A shrub 0.5–2 m. tall, with short rigid branches, the bark pale, the twigs puberulent: leaves numerous; blades mainly linear-spatulate, 1–2.5 cm. long, remaining thin, entire, deep green above, pale beneath: flowers nearly sessile on the branches: bracts obovate to orbicular-cuneate, 1.5–2 mm. long, ciliate: sepals minute or obsolete: drupes oval, 6–9 mm. long, nearly black: stone 5–6 mm. long.

A species related to the western *Adelia angustifolia* and with much the same habit; differing in the less pronounced spatulate lustrous leaf-blades and the equilateral fruit. The type-specimens were collected in the pinelands between Homestead and Camp Jackson by Dr. Britton, March, 1904 (no. 209, fruit), and by Mr. P. Wilson and the writer, May, 1904 (nos. 1600 and 1883, flower).

Adelia globularis sp. nov.

An intricately branched shrub 1–3 m. tall, the branches mainly spreading or recurved, pale gray and striate: leaves approximate during anthesis, remote at maturity; blades oblong, elliptic or slightly broadened upward, leathery-fleshy, mainly 1–2 cm. long, slightly paler beneath than above: flowers few, nearly sessile: bracts oval to suborbicular, 2–2.5 mm. long, ciliate: sepals minute or obsolete: drupes globular, 7–9 mm. in diameter, blue: stone oval, 5.5–6.5 mm. long, longitudinally ribbed.

A species related to *Adelia porulosa*, readily separated by the small thick leaf-blades and the globular fruit. The type-specimens were collected on sand ridges east of St. Augustine, Florida, by the writer, November 29, 1903 (fruit), and by Mr. P. Wilson and the writer, at the same station, May, 1904 (nos. 2013, 2017 and 2034, flower).

Achras Sapota L.

As in the case of *Mangifera Indica* L. the sapodilla-tree has become naturalized in the hammocks about Miami and Cutler. Specimens were collected by Mr. J. J. Carter and the writer in hammocks between Cocoanut Grove and Cutler, in November, 1903 (no. 1310).

Voyria Mexicana Griseb.

Recent exploration on the mainland of Florida south of Miami has shown this species, heretofore known as a member of the North American flora only from some of the Keys, to be quite common in many of the dense hammocks. Specimens were collected in

hammocks near the Homestead trail between Cutler and Camp Longview, by Mr J. J. Carter and the writer, November, 1903 (no. 850), and in the same region by Dr. Britton in March, 1904 (no. 256).

Rhabdadenia corallicola sp. nov.

Stems solitary or several together from an irregular root, woody at the base, sometimes reclining, 3–11 dm. long, finely pubescent to the inflorescence, the hair-bases persistent on the old bark: leaves opposite; blades leathery, oblong or nearly so, 1–3 cm. long, dark green and lustrous above, pale green beneath, glabrous, revolute, rounded at the base, short-petioled: flowers pedicelled: calyx-lobes deltoid-ovate, 2–2.5 mm. long, becoming slightly acuminate, and with spreading tips: corolla yellow, 2.5–3 cm. long; tube 5–6 mm. long; throat campanulate; lobes spreading, rounded: follicles 2 together, slender, 8–11 cm. long: seeds 4.5–5 mm. long, narrowed at the apex.

An erect or reclining vine related to the twining West Indian *Rhabdadenia Sagraei* (A. DC.) Muell. Arg.; characterized by the narrower lustrous leaf-blades merely rounded at the base. The type-specimens were collected in the pinelands between Cocoanut Grove and Cutler, in November, 1903 (*Small & Carter*, no. 714).

Other specimens belonging to this species are:

Between Cutler and Camp Longview, *Small & Carter*, no. 848.

Between Homestead and Camp Jackson, *Small & Wilson*, no. 1951.

Long Key (mainland), *Small & Wilson*, no. 1850.

Perrine, *Britton*, no. 277.

Ipomoea fuchsioides Griseb.

This exceedingly showy vine is widely distributed in the homestead region south of Cutler. It was found in pinelands near Camp Longview and at Black Point, by Mr J. J. Carter and the writer, November, 1903 (nos. 788 and 816), and in May, 1904, on Long Key (mainland) by Mr. P. Wilson and the writer (no. 1971).

Ipomoea tenuissima Choisy

This vine is quite common on the sand rock ridge south of Cocoanut Grove. It was previously known only from Cuba. The first specimen found in Florida was collected by Mr J. J. Carter and the writer in the pinelands between Cocoanut Grove and Cutler, November, 1903 (no. 712). Dr Britton found it south of Cutler

in March, 1904 (no. 163), while Mr Wilson and the writer found it growing plentifully still further south in May, 1904 (Nos. 1705, 1834 and 1953).

Jacquemontia reclinata House, sp. nov.

Stem branched at the base or near it, the branches trailing or prostrate, mostly again branched, the foliage tomentulose, or the older leaves becoming glabrate: leaf-blades oblong to ovate-orbicular, 1–3 cm. long, 0.5–2.5 cm. broad, rounded or obtuse at the base, obtuse or retuse and mucronate at the apex, more or less densely tomentulose beneath, less so or glabrate above, the margins apparently never revolute; petioles 2–10 mm. long: peduncles exceeding the subtending petioles but not the blades, 1–5-flowered, the pedicels about as long as the peduncle: calyx-lobes subequal, ovate, obtuse, 1.5–2 mm. long: corolla white, rotate funnelform, 2.5–3 cm. broad, 5-lobed, the lobes broadly ovate, obtuse: capsule globose, 4–5 mm. in diameter, 4-seeded, 8-valved: seeds minutely scabrous with narrowly winged angles.

Differs from *Jacquemontia Jamaicensis* (Jacq.) Hallier (*Convolvulus Havanensis* Griseb.), by its merely reclining stem and branches, its tomentulose foliage, broad leaf-blades which are not revolute, smaller calyx with broader and less acute lobes, the shorter and broader lobes of the corolla which are barely acute, and the globose capsule. The type-specimens were collected on Bull Key, opposite Lemon City, in November, 1903 (*Small & Carter*, no. 630). Specimens referable to this species were collected at Palm Beach, Florida, in April, 1897, by Mr. A. H. Curtiss (no. 5860).

Heliotropium horizontale sp. nov.

Perennial from a stout woody root, forming depressed mats: stem branched at the base, the branches prostrate, 1–4 cm. long, commonly branched, strigose: leaves numerous, spreading; blades linear or nearly so, 8–16 mm. long, acute, strigillose, short-petioled: racemes spike-like, many-flowered: calyx less strigose than the stem; lobes lanceolate, 4–5 mm. long, acute: corolla golden yellow; tube sparingly pubescent, about as long as the calyx; limb spreading, 7–9 mm. broad: nutlets 2 mm. high.

A species related to *Heliotropium Leavenworthii* Torr.; but with radiating prostrate branches, golden yellow corollas, larger calyx-lobes and larger nutlets. The type-specimens were collected in the pinelands between Cutler and Camp Longview, in November, 1903 (*Small & Carter*, no. 742). Other specimens from the same region are as follows:

Cocoanut Grove, *Small & Nash*, no. 175.

Between Cocoanut Grove and Cutler, *Small & Carter*, no. 552.

Between Cutler and Camp Longview, *Small & Carter*, no. 867.

Between Cocoanut Grove and Cutler, *Small & Wilson*, no. 1833.

Lantana depressa sp. nov.

A depressed unarmed shrub, the branches radiating, prostrate, reddish or purplish, more or less hispid: leaves numerous; blades ovate to elliptic, 1–3.5 cm. long, crenate or serrate-crenate, finely pubescent, at least when young: spikes usually numerous, showy: bracts lanceolate, 4–5 mm. long, sparingly pubescent: calyx campanulate, 2 mm. long, 2-lobed, the lobes erose: corolla golden yellow, 9–11 mm. long; tube minutely pubescent, slightly enlarged near the middle; limb spreading, the upper lip much broader than long, the lower lip 3-lobed, the middle lobe reniform: stamens 4; filaments scarcely as long as the anthers: drupes purplish black, globular-oval, 4–5 mm. long.

This characteristic species differs from *Lantana Camara* L. in its prostrate unarmed branches and smaller flowers. The type-specimens were collected in the pinelands between Cocoanut Grove and Cutler in November, 1903 (*Small & Carter*, no. 747). Other specimens from the same region belonging here are:

Cocoanut Grove, *Small & Nash*, no. 180.

Gossmans, *Britton*, no. 156.

Black Point, *Small & Wilson*, no. 1826.

Verbena maritima sp. nov.

Perennial, sparingly pubescent; stems branched at the base, the branches decumbent or prostrate, 2–5 dm. long, obtusely 4-angled: leaf-blades cuneate to orbicular-ovate, 1–4 cm. long, incisely few-toothed or somewhat lobed, mainly larger than the petiole-like bases: spikes few, many-flowered: calyx slightly bristly-pubescent, 9–10.5 mm. long, about twice as long as the bract; lobes subulate: corolla purplish; tube nearly twice as long as the calyx, pubescent without and within; lobes emarginate: anthers without glands in the connective: nutlets about 4 mm. long, ridged near the base, pitted from below the middle to the apex.

A species related to *Verbena Tampensis* Nash; differing in the smaller, incisely few-toothed or lobed leaf-blades, the glandular calyx and the shorter and broader calyx-lobes. The type-specimens were collected in the pinelands, near Camp Longview, in November, 1903 (*Small & Carter*, no. 1077). Other specimens collected south of Miami are as follows:

Between Camp Jackson and Long Key (mainland), *Britton*, no. 220; *Small & Wilson*, no. 1961.

Cape Florida, *Britton*, no. 296.

Scutellaria longiflora sp. nov.

Perennial, minutely hoary-pubescent: stem usually branched at the base; the branches erect or nearly so, 1–3 dm. tall, sometimes sparingly branched above, the hairs ascending: leaf-blades orbicular-ovate to ovate, 3–6 mm. long, obtuse, minutely pubescent on both sides, those of the lower leaves sometimes shallowly toothed, those of the upper entire, all short-petioled: pedicels about as long as the mature calyx, subtended by very small bracts similar to the leaves: calyx about 1.5 mm. long during anthesis, becoming 3 mm. long, the relatively large crest about the middle: corolla deep blue, about 1.5 cm. long; tube gradually from about the middle to the top; the middle lobe of the upper lip notched, the lower lip broadly and shallowly 3-lobed: nutlets slightly over 1 mm. long, shallowly papillose.

A species related to *Scutellaria Havanensis* Jacq., differing in its erect stem, copiously pubescent and thick leaf-blades, and shaggy pubescent corolla. The type-specimens were collected in the pinelands near Camp Longview in November, 1903 (*Small & Carter*, no. 1094). Specimens belonging to this species have been collected both on the mainland and in the Bahamas, viz.:

Eleuthera, Bahamas, *Coker*, no. 388.

Between Homestead and Camp Jackson, Florida, *Small & Carter*, no. 1670.

Ruellia succulenta sp. nov.

Stems solitary or slightly tufted, 1.5–5 dm. tall, succulent, mainly simple, sometimes with few erect or nearly erect branches, purplish or greenish purple minutely and inconspicuously puberulent, the internodes long, those on the lower part of the stem very long, the nodes somewhat enlarged: leaves opposite, distant, rather fleshy; blades narrowly oblong to spatulate, 2.5–4.5 cm. long, purplish or greenish purple, narrowed into short petiole-like bases: calyx about 1.5 cm. long; lobes linear-filiform, sparingly ciliate: corolla purplish blue, about 4 cm. long; finely pubescent, the funnelform throat about as long as the tube; limb 3.5–4.5 cm. broad, the lobes ovate or orbicular-ovate: capsule oblong or nearly so, abruptly contracted into the stipe-like base which is not manifest beyond the calyx-tube, about as long as the calyx-lobes.

A characteristic species, growing scattered or in colonies, with stiffly erect simple or nearly simple succulent more or less fistulose

stems, thus differing from *Ruellia parviflora* (Nees) Britton, with its firm diffusely branched hispid or hispidulous stems. The type-specimens were collected in the everglades between Cutler and Camp Longview in November, 1903 (*Small & Carter*, no. 1271, flowers, and no. 1271*a*, fruit). It was also found at Black Point (*Small & Carter*, no. 1101).

Ernodea angusta sp. nov.

A spreading or prostrate shrub, the branches sometimes elongated, clothed with a gray bark: leaves numerous; blades leathery, linear or nearly so, 2–4 cm. long, acute, entire, glabrous, sessile: flowers nearly sessile: sepals linear-lanceolate, 2.5–3 mm long, acute, nearly half as long as the corolla-tube: corolla whitish; tube slightly exceeding the length of the hypanthium and calyx, generally 10 mm. long; lobes linear or nearly so, about 5 mm. long: filaments as long as the corolla-tube: drupes oval, 5–6 mm. long.

Quite common on the coral-sand rock, related to *Ernodea littoralis* Sw.; differing in the narrow leaf-blades and smaller flowers. The type-specimens were collected in the pinelands between Cutler and Camp Longview in November, 1903 (*Small & Carter*, no. 870). Specimens similar to the originals were found in the homestead region by Dr. Britton in March, 1904 (no. 191).

CAYAPONIA RACEMOSA (Sw.) Cogn.

This member of the West Indian flora was first found in Florida in hammocks along the homestead trail between Cutler and Camp Longview by Mr. J. J. Carter and the writer, November, 1903 (no. 792). It was again collected by Mr. P. Wilson and the writer in the same region, May, 1904 (no. 1593).

WILLUGHBAEYA CORDIFOLIA (L.) Kuntze

This twiner, common throughout the West Indies, was found in dense hammocks near the homestead trail between Cutler and Camp Longview, by Mr. J. J. Carter and the writer, November, 1903 (no. 989).

BACCHARIS DIOICA Vahl.

This well-marked species of *Baccharis* was first found in Florida by Dr. Britton on rocks in the hammock south of Miami in March, 1904 (no. 72). It was later, May 1904, collected in the same hammock by Mr. P. Wilson and the writer (no. 1651).

Melanthera ligulata sp. nov.

Perennial, often luxuriant: stem commonly branched at the base and above, the branches spreading or ascending, 4–7 dm. long, finely pubescent: leaves conspicuously elongated; blades linear or nearly so, mainly 8–17 cm. long, irregularly toothed and sometimes salient at the base, attenuate into long petioles: heads long-peduncled: involucres partly foliaceous, the outer bracts surpassing the disk, linear-lanceolate, 11–13 mm. long, finely pubescent; the inner bracts lanceolate, 8–10 mm. long, acuminate: bractlets linear-lanceolate, 5.5–6.5 mm. long, pubescent at the tip: corollas 5–6 mm. long; lobes ovate: achenes not seen.

A species related to *Melanthera lanceolata* Benth., but readily separated by the peculiarly elongated leaves and the foliaceous involucre with its long and acuminate bracts. The type-specimens were collected in the pinelands below Ft. Lauderdale, by Mr. P. Wilson and the writer, in May, 1904 (no. 1775).

Carduus vittatus sp. nov.

Perennial, the rootstock often branched: stem 4–7 dm. tall, simple, ridged in age: leaves mainly basal; blades elongated-linear, mostly 1–3 dm. long, acute, spinescent-ciliate on the margins, thinly floccose on each surface; stem-leaves few, remote, erect or ascending; blades shorter than those of the basal leaves, more coarsely spinescent-ciliate, clasping at the base: involucre subtended by a series of spine-armed bracts, hemispheric-campanulate, nearly 3 cm. high; bracts acuminate, ciliate, the outer lanceolate, the inner ones linear-lanceolate or nearly linear, surpassing the spine-armed outer bracts: anthers twice as long as the free portion of the filaments: achenes 3–3.5 mm. long, glabrous, angled: pappus white, the bristles plumose.

A small species related to *Carduus pinetorum* Small; differing in the narrow elongated blades of the basal leaves which are not pinnatifid, the campanulate involucres and the throat of the corolla which is scarcely half as long as the lobes. The type-specimens were collected in the everglades west of Camp Jackson in May, 1904 (*Small & Wilson*, no. 1874). Other specimens belonging here are:

Between Cutler and Camp Longview, *Small & Carter*, no. 1087.
Near Camp Longview, *Small & Wilson*, no. 1794.

CHAPTALIA LEIOCARPA (Griseb.) Britton

This, the second species of *Chaptalia* for the North American flora, was discovered in the everglades near the homestead trail

between Cutler and Camp Longview, by Mr. J. J. Carter and the writer, November, 1903 (no. 1107).

Sachsia Bahamensis Urban

This recently described species, originally from the Bahamas, occurs quite plentifully in the pinelands from several miles below Cutler to Camp Jackson on the southern end of the sandrock ridge. It was first found in the homestead country by Dr. Britton in March, 1904 (no. 159). Later, May, 1904, it was collected in the same region and much further southward by Mr. P. Wilson and the writer (nos. 1722, 1881, and 1917).

Contributions to the Flora of the Bahama Islands.—I.

By N. L. Britton.

It is proposed to present in this paper and others which will follow it, records of the occurrence of rare or otherwise interesting plants of the Bahama Islands, looking forward to the publication of a flora of that archipelago, to be prepared in coöperation with Dr. C. F. Millspaugh, of the Field Columbian Museum. An extensive system of exploration of the Islands has been planned and partially carried out.

Coccothrinax jucunda Sargent.

Common in sandy soil on New Providence (*Curtiss*, *102*; *Northrop*, *284*; *Britton & Brace*, *297*, *747*). Also on South Bimini (*Millspaugh*, *2357*); Little Inagua (*Nash & Taylor*, *1247*).

Inodes Palmetto (Walt.) O. F. Cook.

Identical with the Florida tree. Common in moist or wet soil on New Providence.

Tillandsia polystachya L.

Frequent on trees in coppice land on New Providence (*Britton & Brace*, *357*, *574*).

Tillandsia circinata Schlecht.

On trees in coppice south of Fox Hills, New Providence (*Britton & Brace*, *542*); Salt Pond Hill, Inagua (*Nash & Taylor*, *939*). Previously found by Eggers on Fortune Island (*Eggers*, *3855*).

Tillandsia usneoides L.

Uncommon in the Bahamas. On trees, Maidenhead Coppice, New Providence (*Britton & Brace*, *238*); James Hill, Inagua (*Nash & Taylor*, *1179*).

Atamosco rosea (Lindl.) Greene.

Abundant on roadsides near Nassau (*Britton & Brace*, *415*). Evidently escaped from cultivation.

Phoradendron spathulifolium (Griseb.) Krug & Urban.

Occasional on *Swietenia Mahagoni* in the coppices on New Providence (*Coker*, *303*; *Britton & Brace*, *832*). Also found by *Eggers* on Fortune Island, and abundantly by *Nash &*

Taylor on Inagua. *Phoradendron rubrum* (L.) Krug & Urban, based on Catesby's *plate 81*, has *S. Mahagoni* for its host, but the figure represents a plant with long-petioled leaves: nothing just like it has come from the Bahamas recently, and I suspect it to really be the same as *P. spathulifolium*, badly illustrated.

According to Mr. Brace's observations this species occurs only on mahogany on New Providence.

SCHOEPFIA OBOVATA Wright.

Frequent in the coppice lands of New Providence, a bush up to 2 m. in height (*Brace, 324; Northrop, 71; Curtiss, 82; Britton & Brace, 207, 325*).

AMARANTHUS CRASSIPES Schlecht.

Waste grounds, Ft. Charlotte, New Providence (*Britton & Brace, 778*).

ALTERNANTHERA MARITIMA St. Hil.

On the sea beach, Southwest Bay, New Providence, forming runners 3 meters long (*Britton & Brace, 478*); Little Mangrove Cay, Andros (*Coker, 196*); South Bimini (*Millspaugh, 2353, 2410*).

ANONA GLABRA L.

Common along marshes and in sink-holes on New Providence (*Britton & Brace, 301, 384*). The species is based on Catesby's *plate 64*, which is apparently erroneous in representing the leaves cuneately narrowed at the base.

CORONOPUS DIDYMUS (L.) J. E. Smith.

Cultivated ground near Nassau (*Britton & Brace, 790*).

PROSOPIS JULIFLORA (Sw.) DC.

Mathew Town, Inagua, probably introduced (*Nash & Taylor, 1065*).

ACACIA ACUIFERA Benth.

Frequent on "white land" on Inagua (*Nash & Taylor, 1347, 1350, 1420*). The same as *Brace, 449* and *459*, from Fortune Island; called Rosewood on Inagua. The trunk and main branches are armed with stout stiff clustered spines 5-8 cm. long.

Pithecolobium flavovirens sp. nov.

A glabrous shrub, about 3 m. high, the branches stout. Petioles slender, grooved on the upper side, 3 cm. long or less; petiolules

3–6 mm. long, each bearing 2 sessile leaflets; leaflets obliquely ovate to obovate, firm in texture, 2.5–4 cm. long, 3.5 cm. wide or less, obtuse or emarginate, not mucronate, the upper surface bright green, with conspicuously reticulated yellow veins, the under side dull green, and the veins less conspicuous; flowers not seen; heads racemose, evidently numerous, the fruiting peduncles 1–1.5 cm. long; legume twice curved, 9 cm. long or less, 1 cm. wide, narrowed at the base, blunt at the apex, its margins slightly elevated; seeds suborbicular, black, shining, 7 mm. broad.

Sheep Key, Inagua (*Nash & Taylor*, *1143*).

CASSIA CARIBAEA Northrop.

This species, hitherto known only from Andros, occurs in the coppice along Soldiers' Road, New Providence (*Britton & Brace*, *678*).

Cassia Inaguensis sp. nov.

A much branched shrub, 6–12 dm. high, the twigs pubescent. Leaflets 1 or 2 pairs, glabrous, coriaceous, rigid, shining, oblong to oblanceolate, strongly and finely many-veined, emarginate or rounded at the apex, narrowed but not cuneate at the base, more or less inequilateral, 1.5–3 cm. long, 5–13 mm. wide; petiole 2–6 mm. long, sparingly pubescent, bearing a stipitate gland near the apex; stipules lanceolate-subulate, 2–4 mm. long, pubescent, persistent; flowers solitary in the axils, numerous, the filiform sparingly pubescent peduncles 2–3 cm. long; sepals pubescent, at least at the base, obliquely lanceolate, acuminate, 1 cm. long or less; petals golden yellow, about 1.5 cm. long; young legume densely pubescent.

Inagua (*Nash & Taylor*, *910*, type; *1261*).

Apparently nearest to *C. lineata* Sw.

CASSIA ASPERA Muhl.

Apparently identical with the Florida plant, though reported by Dolley as *C. glandulosa* L.; common in pine and palmetto lands on New Providence (*Brace 428*, *433; Britton*, *28; Britton & Brace*, *427*); Eleuthera (*Coker*, *402*).

MEIBOMIA TORTUOSA (Sw.) Kuntze.

Grantstown (*Brace*, *119*); along path, Waterloo, New Providence (*Britton & Brace*, *723*). Apparently introduced.

Bursera Inaguensis sp. nov.

A shrub or small tree, 3.3 m. high or less, the twigs gray, the foliage glabrous. Petiole slender, terete, 2–5 cm. long; leaflets 3–7, thin but firm, light green both sides, not strongly veined, oblong to oblanceolate or obovate, acute or obtuse at the mucronate apex, narrowed or cuneate at the base, 6 cm. long or less, 1–2 cm. wide,

the upper surface faintly shining, the under side dull; lateral leaflets sessile or with petiolules 1–2 mm. long, the terminal one with a petiolule 3–8 mm. long; panicles several, axillary, as long as the leaves or shorter, the slender peduncles 1–6 cm. long; pedicels 2–3 mm. long; calyx-teeth broadly triangular, acute; petals oblong-lanceolate, acute, 2.5 mm. long; fruit 6–8 mm. long, only one cavity seed-bearing; seed 4–6 mm. long, acute, short-stipitate.

Moujean Harbor, Little Inagua, Oct. 20, 1904 (*Nash & Taylor*, *1190*, type; *1204*, *1205*); abundant on Inagua (*Nash & Taylor*, *1279*, *1329*, *1393*). Erroneously referred by Hitchcock in Ann. Rep. Mo. Bot. Gard. 4: 69, to *Bursera angustata* Griseb., of Cuba.

DRYPETES DIVERSIFOLIA Krug & Urban, Bot. Jahrb. 15: 353. 1893.

Drypetes Keyensis Krug & Urban, *loc. cit.* 354. 1893.

These names turn out to belong to the same species, and *diversifolia* has precedence. The type locality of this is Hog Island, off New Providence (*Eggers*, *4125*), where it is abundant, and it is seen in all the coppice area of New Providence, sometimes reaching a height of 15 m., with a trunk up to 4 dm. in diameter (*Britton & Brace*, *348*, *661*, *808*, *859*). Its bright white ripe oval fruits, which are 2 or 3 cm. long, are very conspicuous; when young they are oval or oblong and finely pubescent. The leaves of seedlings are always spiny-toothed, and those of *D. Keyensis* are identical; they are well shown in *Simpson's 211* from Bahia Honda, Florida, and I observed them on Sand's Key, Florida. It was such leaves that induced Professor Urban to propose the name *diversifolia;* at the time the species was described he had seen neither flowers nor fruit of it. What appears to be the same species occurs on Inagua, with falcate leaves (*Nash & Taylor*, *965*, *1328*).

ACALYPHA SETOSA A. Rich.

New Providence (*Brace*, *267*).

ACALYPHA OSTRYÆFOLIA Ridd.

New Providence (*Brace*, *385*), probably introduced from the southern United States.

BONAMIA CUBANA A. Rich.

New Providence (*Brace*, *141*, *340*); Cat Island (*Coker*, *428*).

GYMINDA LATIFOLIA (Sw.) Urban [*G. Grisebachii* Sargent].

Frequent on Inagua (*Nash & Taylor*, *987*, *889*, *1061*, *1283*), shrubby or forming a tree, 3.3 m. high; also at Clarence Harbor,

Long Island (*Coker*, *504*). Not yet found in the northern Bahamas.

CASSINE ATTENUATA (Rich.) Kuntze.

A single tree, about 5 m. high, occurs on the south shore of Lake Cunningham, from which fruiting specimens were obtained (*Britton & Brace*, *626*). Also found between Camfield Bay and Cabbage Pond, Inagua (*Nash & Taylor*, *1306*). The specimens seem to be inseparable specifically from *Wright's* Cuban numbers, *1144* and *2206* (*Elaeocarpum xylocarpum attenuatum* (Rich.) Urban), though the leaves are more strongly revolute-margined. Prof. Urban has founded the subspecies *E. xylocarpum Bahamense* (Symb. Ant. 5 : 88) on *Eggers*, *3874*, from Fortune Island, but I have not seen this specimen; from his description I think it likely to be the same as the Lake Cunningham plant.

ALLOPHYLUS COMINIA (Sw.) Radlk.

Frequent in the coppice at Waterloo, New Providence (*Britton & Brace*, *715*).

DODONAEA EHRENBERGII Schlecht. (*D. viscosa obovata* Hitchc. Rep. Mo. Bot. Gard. 4 : 73. 1893).

Common on the Bahamas: Inagua (*Nash & Taylor*, *955*, *1032*, *1035*, *1107*, *1421*); Rum Cay (*Coker*, *444*); Cat Island (*Hitchcock*); New Providence (*Curtiss*); Abaco (*Coker*, *567*). Distinct from *D. viscosa* by its small spatulate to obovate leaves, and the small fruit. The type locality of this species is Santo Domingo.

REYNOSIA NORTHROPIANA Urban, Symb. Ant. 3 : 315.

Sandy coppice near Old Fort, New Providence (*Britton & Brace*, *708*). Known hitherto only from Red Bays, Andros, and described from flowering specimens. As seen by us it becomes a tree 5 m. high, the mature leaves thick, 5–6 cm. long and 1.5–2.5 cm. broad, finely reticulate-veined, nearly all of them emarginate; the fruit is oval, 1 cm. long, 8 mm. in diameter, the flesh thin; fruiting pedicels 5–6 mm. long.

Sarcomphalus Taylori sp. nov.

A glabrous, densely branched shrub, 1 m. high or less, some of the branches long and prostrate, the bark gray, the twigs green, angled, unarmed, or occasionally with a spine 1–2 cm. long in the upper axils. Leaves alternate, obovate, bright green on both sides, but a little paler beneath than above, 1.5–2.5 cm. long, 2 cm. wide or less, emarginate or rounded at the apex, narrowed at the base, 3-nerved just above the base, the veins elevated on the upper surface,

and impressed in the lower; petioles 2 mm. long; flowers in small clusters at the ends of the branches, green, glabrous, 3 mm. broad, on pedicels 2 mm. long; calyx campanulate, 5-lobed, the lobes ovate, acute, 1 mm. long; petals clawed, hooded, about as long as the calyx-lobes and the stamens; ovary oblong, tipped with two slightly divergent styles.

Inagua, on Salt Pond Hill (*Nash & Taylor*, *961*, type); Moujean Harbor, Little Inagua (*Nash & Taylor*, *1199*).

CORCHORUS OLITORIUS L.

Waste and cultivated soil on New Providence; naturalized (*Brace*, *127*, *202*; *Britton & Brace*, *632*).

SIDA SUPINA L'Her.

Waste grounds, New Providence (*Britton & Brace*, *659*).

SIDA SPINOSA L.

Waste grounds, common on New Providence. Naturalized from the United States.

PARITIUM TILIACEUM (L.) Juss.

Borders of swamp near Old Fort, New Providence, the only locality for this species observed on that island (*Britton & Brace*, *710*); known also from Andros (*Northrop*, *564*).

ISNARDIA NATANS (Ell.) Small.

Frequent in wet sink holes and on borders of marshes, New Providence (*Eggers*, *4339*; *Britton & Brace*, *200*). This appears to me as probably distinct from *I. repens* (Sw.), DC., though the two are united by Grisebach in Fl. Br. W. I.

EUGENIA FILIFORMIS Macf.

In the coppice at Waterloo, New Providence (*Britton & Brace*, *762*). Growing with *E. confusa* DC., and quite distinct from it, the narrowly lanceolate, very long-acuminate leaves being characteristic. Apparently identical with Jamaica specimens.

EUGENIA RHOMBEA (Berg.) Kr. & Urb.

Frequent in scrub lands on Inagua (*Nash & Taylor*, *886*, *948*, *1429*).

Opuntia Nashii sp. nov.

Tree-like, dull green. Main axis round, 1–4 m. high, 5–12 cm. in diameter, spiny; branches flat or becoming round below, the principal ones continuous, 1 m. long or more, 6 cm. wide or less, crenate, blunt; lateral branches opposite or alternate, oblong to linear-oblong, often 3 dm. long, and 8 cm. wide, only about 6 mm. thick, blunt, crenate; areoles 1–3 cm. apart, slightly elevated;

spines mostly 5 at each areole (2–5), divergent, slender, straight, light gray, pungent, the longer 3–5 cm. long; glochides very small, brownish; ovary 3 cm. long, 1.5 cm. thick, somewhat clavate, tubercled, the tubercles bearing areoles and spines similar to those of the joints, but the spines somewhat shorter; flowers 1.5 cm. broad when expanded, red; petals broadly oval to obovate, blunt, about 8 mm. long, much longer than the stamens.

Inagua (*Nash & Taylor, 1063*). Apparently to be referred to the section Cruciformes, as a relative of *O. spinosissima* Mill., the type locality of which is Jamaica.

PROSERPINACA PLATYCARPA Small, Bull. N. Y. Bot. Gard. 3 : 432.

In fresh water marshes and sink holes, New Providence (*Curtiss, 144; Britton & Brace, 515*). The same as the plant of southern Florida.

HYDROCOTYLE SPICATA Lam.

Among grass, edge of a garden, near Nassau (*Britton & Brace, 791*).

Bumelia loranthifolia (Pierre) Britton.

Bumelia retusa loranthifolia Pierre; Pierre & Urban, Symb. Ant. 5: 145. 1904.

I take this up as specifically distinct from the Jamaican *B. retusa* Sw. It is very abundant on New Providence, the type locality (*Eggers, 4228; Curtiss, 85; Coker, 20, 156; Brace, 115; Britton, 44, 88; Britton & Brace, 283, 290, 315, 351, 538*), and is known also from several of the other islands. Its leaves vary greatly in size on individual bushes from 2 cm. to 4 cm. long, and from obovate-cuneate to nearly orbicular. Its fruit is jet black, shining, oblong to globose, 12 mm. long or less; the pedicels are not more than twice as long as the flowers; flowers white, fragrant.

Bumelia Bahamensis sp. nov.

A shrub with slender puberulous twigs, related to *B. loranthifolia*. Leaves spatulate-oblanceolate, coriaceous, revolute-margined, 8 cm. long or less, 1.5–2.5 cm. wide, rounded at the apex, narrowly cuneate at the base, dull green and glabrous above, densely brown-tomentulose beneath, rather strongly pinnately veined, the veins ascending at a narrow angle; petioles stout, 5 mm. long or less; flowers about 6 in each axillary cluster; pedicels brown-furfuraceous, stout, 8–10 mm. long, three times as long as the calyx.

Coastal thicket, Delaport, New Providence (*Britton & Brace, 295*).

Sabbatia simulata sp. nov.

Similar to *S. campanulata* (L.) Torr., of the Atlantic Coast States and hitherto confused with it, but more slender than that species and with smaller white flowers. Plant 4 dm. high or less, the upper leaves narrowly linear, 1–3 cm. long, about 1 mm. wide, the lower spatulate, acute, 4 cm. long or less, 2–5 mm. wide, the basal ones spatulate to orbicular; calyx-lobes narrowly linear, less than 1 mm. wide, nearly as long as the corolla or shorter; corolla 1–2 cm. broad, its segments oval, obtuse; capsule ovoid, about 6 mm. long, tipped by the short style; stigmas narrowly spatulate.

New Providence, in brackish marshes (*Britton*, *58*, type; *Cooper*, *53*; *Curtiss*, *200*; *Coker*, *74*; *Britton & Brace*, *575*); Andros (*Northrop*, *464*); Cat Island (*Coker*, *432*).

Plumiera Inaguensis sp. nov.

A glabrous tree, 5 m. high or less. Leaves obovate, rather thin, the blade 6–10 cm. long, 4–6 cm. wide, emarginate or rounded at the apex, narrowed or cuneate at the base, dark green and shining above, bright green and dull beneath, the numerous veins diverging from the midrib at an angle of about 80°, the midrib impressed on the upper surface, elevated beneath; petioles stout, 1–2 cm. long; peduncle stout, 4–10 cm. long; cyme compound, 8 cm. broad or less, densely many-flowered; pedicels slender, 8–12 mm. long; calyx short-campanulate, slightly 5-lobed, the lobes broad, rounded; corolla white, its tube slender, about 1 cm. long, its 5 lobes narrowly obovate, rounded or slightly emarginate, somewhat longer than the tube; stamens about one-third the length of the corolla-tube; follicles linear, terete, 9 cm. long, 8 mm. in diameter.

Salt Pond Hill, Inagua (*Nash & Taylor*, *960*, type); abundant on Inagua, being represented by nos. *1182* and *1430* of the same collectors.

BRACEA gen. nov. (Apocynaceae)

A shrub, with thick oblanceolate or oblong petioled leaves. Flowers solitary or two together in the upper axils, white or reddish, peduncled. Calyx deeply 5-cleft, its lobes narrowly lanceolate, acute. Corolla nearly salverform, the short tube slightly and gradually dilated above, about as long as the 5 obliquely ovate lobes. Stamens 5, borne near the base of the corolla-tube; filaments short; anthers sagittate, hairy on the back. Follicles long-linear, slightly torulose. Seeds comose.

In honor of L. J. K. Brace, a diligent collector of the Bahamian flora.

Bracea Bahamensis sp. nov.

About 1 m. high, with grayish brown branches leafy only near the ends, the young twigs pubescent. Leaves firm in texture,

revolute-margined, oblong-oblanceolate, obtuse or slightly emarginate at the apex, narrowed at the base, 4–10 cm. long, 1–2.5 cm. wide, bright green above, densely and finely tomentose with the veins prominently reticulated beneath; petioles 4–7 mm. long; flowers appearing with the leaves; peduncles tomentose, about 1 cm. long; calyx-lobes tomentose, 3 mm. long; corolla white with a reddish throat, pubescent outside, smooth within, about 2 cm. broad; follicles 15 cm. long or less, 2 mm. thick, pubescent, striate, pendent.

Frequent in low coppices on New Providence (*Britton & Brace, 526*, type; *Coker, 256; Brace, 404; Britton, 80; Curtiss, 137*); Andros (*Northrop, 537*).

Perhaps congeneric with *Wright, 399*, from Monte Verde, Santiago, Cuba, which has been referred by various writers to *Echites*, *Rhabdadenia*, *Angadenia* and *Mandevilla*, but probably belongs to none of these genera; I do not know its fruit.

Philibertella clausa (Jacq.) Vail.

Abundant along the borders of swamps at Southwest Bay and near Old Fort, New Providence (*Britton & Brace, 482, 770*). This vine climbs on trees to a height of 10 meters and is very conspicuous when in bloom, its abundant white flowers giving it the distant effect of a *Clematis*.

Calonyction aculeatum (L.) House.

A recent inquiry relative to the distribution of the Moon Vine in the British West Indies (Agricultural News, 3: 181) may be answered in part by stating that it is not uncommon on walls about Nassau, New Providence (*Britton & Brace, 698*). Père Duss notes on the label of his *428* from Martinique that it is rare on that island. The species is very abundant in Cuba and in tropical Florida.

Calonyction album (L.) House.

This related species occurs on South Cat Cay (*Millspaugh, 2416*); on Sheep Cay, Inagua (*Nash & Taylor, 1156*), and on Rum Cay (*Coker, 445*); it is frequent on the keys of Florida.

Ipomoea speciosa Walt. (*I. sagittata* Cav.).

In wet sand, back of Southside Beach, New Providence, forming runners 5 m. long (*Britton & Brace, 393*); Nassau (*Coker, 549*).

Evolvulus squamosus sp. nov.

An intricately branched erect shrub, 3 dm. high or less, the slender terete twigs densely appressed-pubescent. Leaves scattered, reduced to mere lanceolate-acuminate scales, 2 mm. long or less, appressed-pubescent; flowers solitary in the upper axils, on appressed-

pubescent pedicels, which are about as long as the calyx; calyx-lobes ovate, acute, appressed-pubescent, one-half as long as the white corolla, or less; corolla about 6 mm. broad, slightly 5-lobed, the broad lobes a little emarginate; stamens a little shorter than the corolla, their filaments filiform, their anthers oval, short; ovary densely pubescent, oblong; styles 2, 2-cleft to about the middle.

New Providence, Bahamas (*Curtiss*, *197*, type; *Britton*, *73*; *Britton & Brace*, *843*); Andros (*Northrop*, *607*).

Related to *E. arbuscula* Poir., originally from Santo Domingo, but with much smaller leaves and a different calyx and corolla. *E. arbuscula* is represented in our collections by a Santo Domingo specimen collected by Bertero, and so determined by Choisy; by *Eggers*, *3823*, from Fortune Island; *Coker*, *336*, from Eleuthera, and by three specimens from Inagua, which differ slightly from the others in being less pubescent and with somewhat longer and narrower leaves (*Nash & Taylor*, *972*, *1111* and *1176*).

LIPPIA STOECHADIFOLIA (L.) H.B.K.

Borders of swamps, Clifton, New Providence (*Britton & Brace*, *745*); Arthurs Town, Cat Island (*Coker*, *430*).

LIPPIA REPTANS H.B.K.

Lower Savannah near Blakeville, Inagua (*Nash & Taylor*, *1131*).

Lantana Bahamensis sp. nov.

Similar to *L. crocea* of Jamaica, and hitherto confused with it. Shrub 1 m. high or less, with slender striate branches, which are smooth or sometimes bear minute prickles less than 0.5 mm. long, the twigs minutely pubescent; leaves thin, oblong-lanceolate, varying from acute to blunt at the apex, more or less narrowed at the base, and somewhat decurrent on the petiole, minutely short-pubescent on both sides, or becoming glabrous above, closely crenate, the primary veins rather conspicuous on the under side; blades 5 cm. long or less, 1.5–2 cm. wide; petioles very slender, 2 cm. long or less; peduncles terminal and axillary, shorter than the leaves; bracts lanceolate, acutish, very pubescent, about 4 mm. long; flowers 8–15 in the heads; calyx 2 mm. long, pubescent, the 2 short lips about equal; corolla bright yellow, its tube slender, pubescent, enlarged above, about 8 mm. long, its limb about 4 mm. wide, irregularly lobed; fruit globose, black, shining, about 3 mm. in diameter.

Abundant in the coppices on New Providence (*Britton & Brace*, *174*, type; *328*; *Curtiss*, *109*; *Coker*, *126*); Andros (*Northrop*, *561*).

Citharexylon Bahamense Millsp., sp. nov.

Tree 4–6 m. high, branches terete, strongly grooved. Leaves oblanceolate, with various apices, some acute, others blunt, rounded,

or emarginate on the same branchlet, smooth and shining above, puberulent and reticulate-veined beneath; inflorescence of axillary racemes, the flowers sessile or nearly so, the bracts minute, acuminate; calyx glabrous, long-campanulate, the border either truncate, slightly denticulate or variously lobed in the same raceme, about half the length of the corolla; corolla glabrous exteriorly, hairy in the tube and throat, the lobes small, orbicular, constricted at the base; pyrenae 4 × 6 mm., dark slate color, crateriform, the apex erose.

Leaves 7–10 cm. × 2–4 cm.; racemes 6–9 cm. long; flowers 1 cm. long.

Type from a coppice on Farringdon Road (*Britton & Brace, 233*); coastal coppice at South West Bay, New Providence (*Britton & Brace, 499*).

Lycium spathulifolium sp. nov.

A glabrous shrub, 1.3 m. high or less, with long slender drooping branches, some of the twigs tipped by spines 2–4 mm. long, the bark gray. Leaves 2–4 together at the nodal cushions, or solitary, spatulate, fleshy, entire, 6–15 mm. long, 1.5–3 mm. wide, obtuse, long-attenuate from above the middle to the base; flowers few, solitary; peduncle filiform, 5 mm. long, gradually thickened above; calyx campanulate, 2–2.5 mm. long, somewhat scurfy, its teeth broadly ovate, obtuse, whitish-lanate; corolla funnelform, white, its tube 4–5 mm. long, its 4 oblong obtusish lobes two thirds as long as the tube.

In coppice, Upper Savannah, Inagua (*Nash & Taylor, 1321*).

Physalis Barbadensis Jacq.

Waste ground, Ft. Charlotte, New Providence (*Britton & Brace, 777*).

Ruellia tuberosa L.

Wet ground, Lake Cunningham (*Britton & Brace, 633*). Not reported from the Bahamas by Lindau in his monograph of West Indian Acanthaceae (Urban, Symb. Ant. 2: 191).

Psychotria Bahamensis Millsp., sp. nov.

Shrubby, glabrous. Leaves thin, lanceolate to oblanceolate, broadest at or above the middle, narrowed to a point at the apex and to the petiole, slightly pilose beneath, especially along the midrib; stipules large, orbicular, dimidiate-sheathing, apiculate; inflorescence paniculate, 4-chotomous, exceeded by the leaves; pedicels blepharose at the axils; calyx shallow-cupuliform, hairy-fringed above, with 5 short, deltoid, hairy teeth; corolla-tube glabrous without, bearded in a ring at the insertions of the filaments within, lobes 5, elliptic, acute, strongly deflexed, nearly as long

as the tube; fruit ellipsoidal; pyrenae plano-convex, 5 × 4 mm., 5-ridged, the ridges flattened, equidistant; albumen flat at the commissure.

Leaves light green beneath, dark above, 8–12 × 2–4 cm., the main veins brick red beneath; near *P. undata* Jacq., from which it differs especially in the hairy calyx, the hairyness of the midveins beneath, the stipules, and the pyrenae. Type from a coppice on the Farringdon Road, Nassau, New Providence, Bahamas, Aug. 24, 1904 (*Britton & Brace, 206*); same locality (*Britton & Brace, 208*); coppice at Winton (*Britton & Brace, 662*); pine lands, Blue Hill Road (*Britton, 17*); and Nassau, March 2, 1903 (*F. S. Earle, 43, 52*).

Scolosanthus Bahamensis sp. nov.

An intricately branched, somewhat resinous shrub, 8 dm. high or less, with gray-brown bark, the young twigs greenish, densely papillose, 4-angled, armed with slender, scattered, pungent, solitary spines 1 cm. long or less. Leaves opposite or fascicled, 2–5 mm. long, thick, papillose, ovate to elliptic, revolute-margined, obtuse, very short-petioled, dark green above, paler beneath; flowers not seen; fruits solitary, oblong to globose, white, soft, 2–4 mm. long.

Occasional in the coppices on New Providence (*Britton & Brace*, from coppice along Village Road, *367*, type; coppice, *Coker, 138*); Fresh Creek, Andros (*Northrop, 646*).

In Mem. Torrey Club, **12**: 67, Mrs. Northrop has given a description of this interesting species, not named there, however.

ERITHALIS ODORIFERA Jacq.

Common in coppices on New Providence, and distinct from the more abundant *E. fruticosa* L., being much taller, the corolla twice as large as in that species, the fruit and persistent calyx-limb larger (*Britton, 147; Coker, 43; Britton & Brace, 234, 580, 605*).

GALIUM HISPIDULUM Michx.

Pine lands, occasional on New Providence (*Brace, 330; Britton & Brace, 429*); Abaco (*Coker, 563*); Andros (*Northrop, 523*, reported as *Galium hypocarpium* Endl., which is Jamaican, inhabiting high mountain woods). The Bahama plant is identical with that of the southeastern states.

IVA IMBRICATA Walt.

Frequent on sandy beaches in the Bahamas. New Providence

(*Britton & Brace, 305*) ; Andros (*Northrop, 716*) ; Inagua (*Nash & Taylor, 1040*).

BACCHARIS ANGUSTIFOLIA Michx.

Edges of swamps near Nassau, locally abundant (*Britton & Brace, 172*). Differs from most, or perhaps all, Florida specimens in the broader leaves, the lower ones sharply 3-lobed near the apex, and in the relatively more acute (even acuminate) bracts of the pistillate involucre.

SACHSIA BAHAMENSIS Urban.

This recently described species is abundant in pine lands on New Providence.

PECTIS LESSINGII Fernald (*P. linifolia* Less., not L.).

Common in open places on New Providence (*Britton & Brace, 193*).

PECTIS LINIFOLIA L. (*P. punctata* Jacq.).

Inagua (*Nash & Taylor, 1397*) ; Little Inagua (*Nash & Taylor, 1219*).

Thymopsis Brittonii Greenman, sp. nov.

A low herbaceous perennial: stems several from a common base, erect or ascending, slender, 4–10 cm. in length, puberulent. Leaves opposite, rhombic-ovate to somewhat spatulate, 4–8 mm. long, one-half as broad, obtuse, entire, revolute-margined, narrowed below to a short petiole, sparingly puberulent to glabrous, dark green above, paler and glandular-punctate beneath; heads terminating the stem and branches, sessile, about 3 mm. high, heterogamous, 5-flowered; involucre of 5 (4) oblong obtuse navicular or somewhat obtusely carinate-concave ciliolate green bracts; corollas all tubular and externally somewhat glandular, those of the 3 outer or pistillate flowers about 1 mm. long, of uniform diameter, shorter than the style, minutely 4-dentate, those of the 2 (3) inner or perfect flowers 1.5 mm. long with the tube expanded above and distinctly 4-toothed; pappus a minutely fringed crown much shorter than the corolla; mature achenes about 1.5 mm. long, striate, glabrous.

Moist palmetto lands, Tea House, New Providence (*Britton & Brace, 595;* hb. Gr. and hb. N. Y. Bot. Gard.).

The only other species of this genus known at the present time is *T. Wrightii* Benth., from which the one here described differs in being slightly puberulent instead of hirsute-hispid throughout, in having about 5 flowers instead of 10 in the head, and in having somewhat shorter achenes. The plant was received for examination through the kindness of Prof. N. L. Britton.

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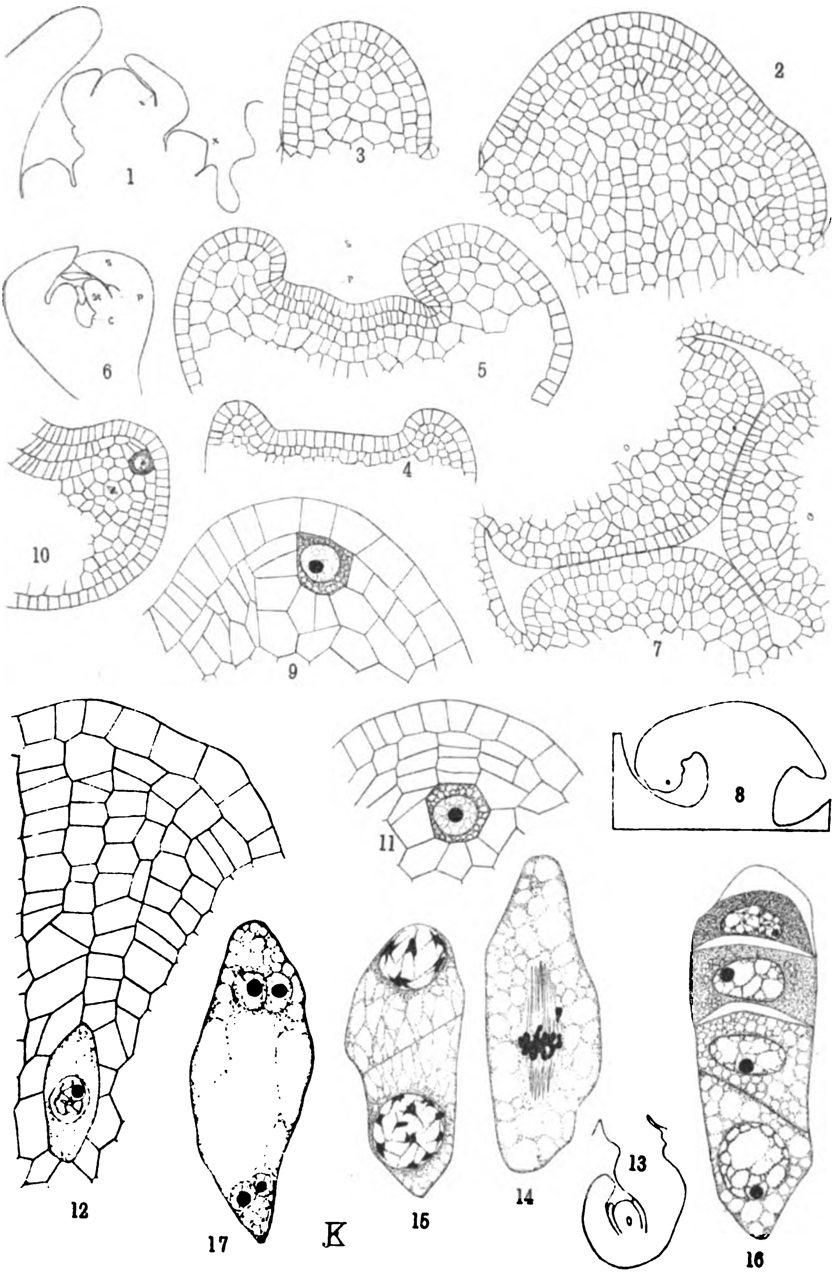
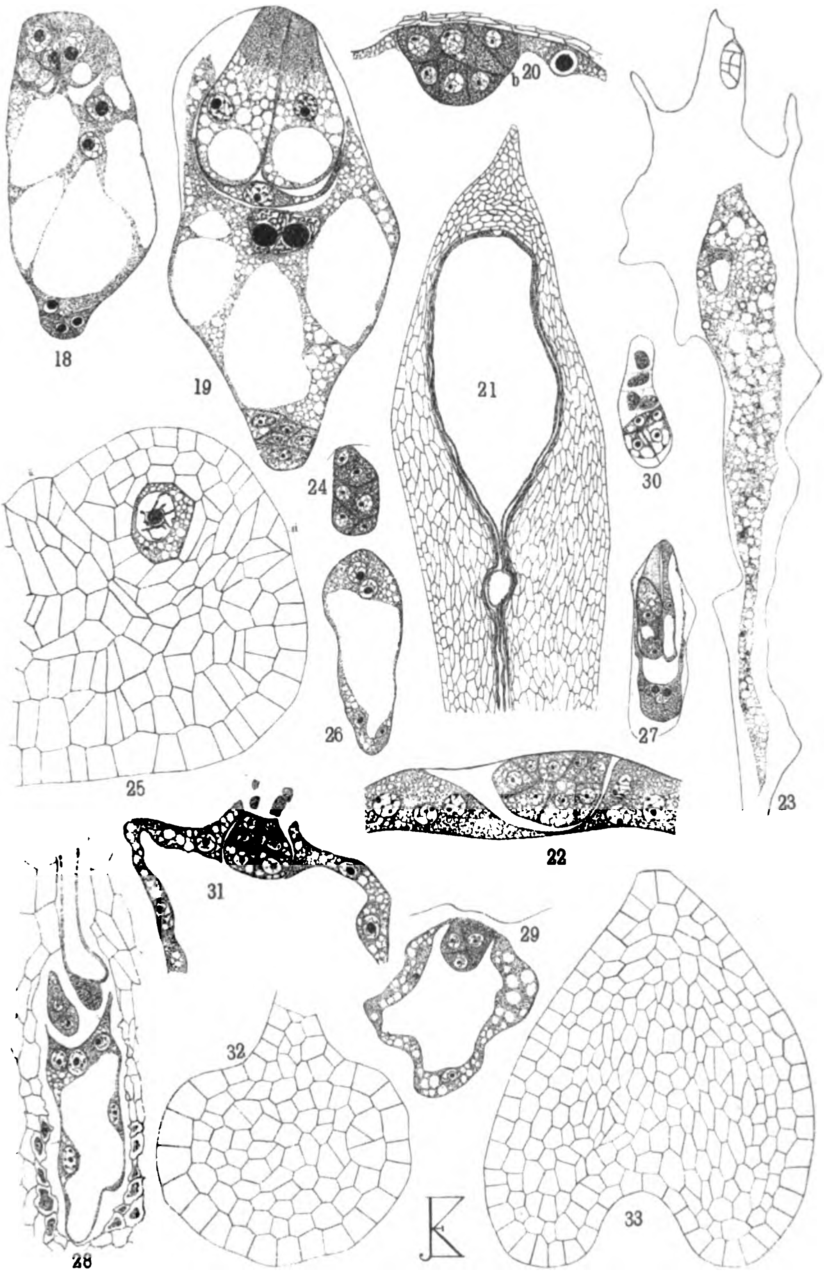


1-17. FEVILLEA CORDIFOLIA.



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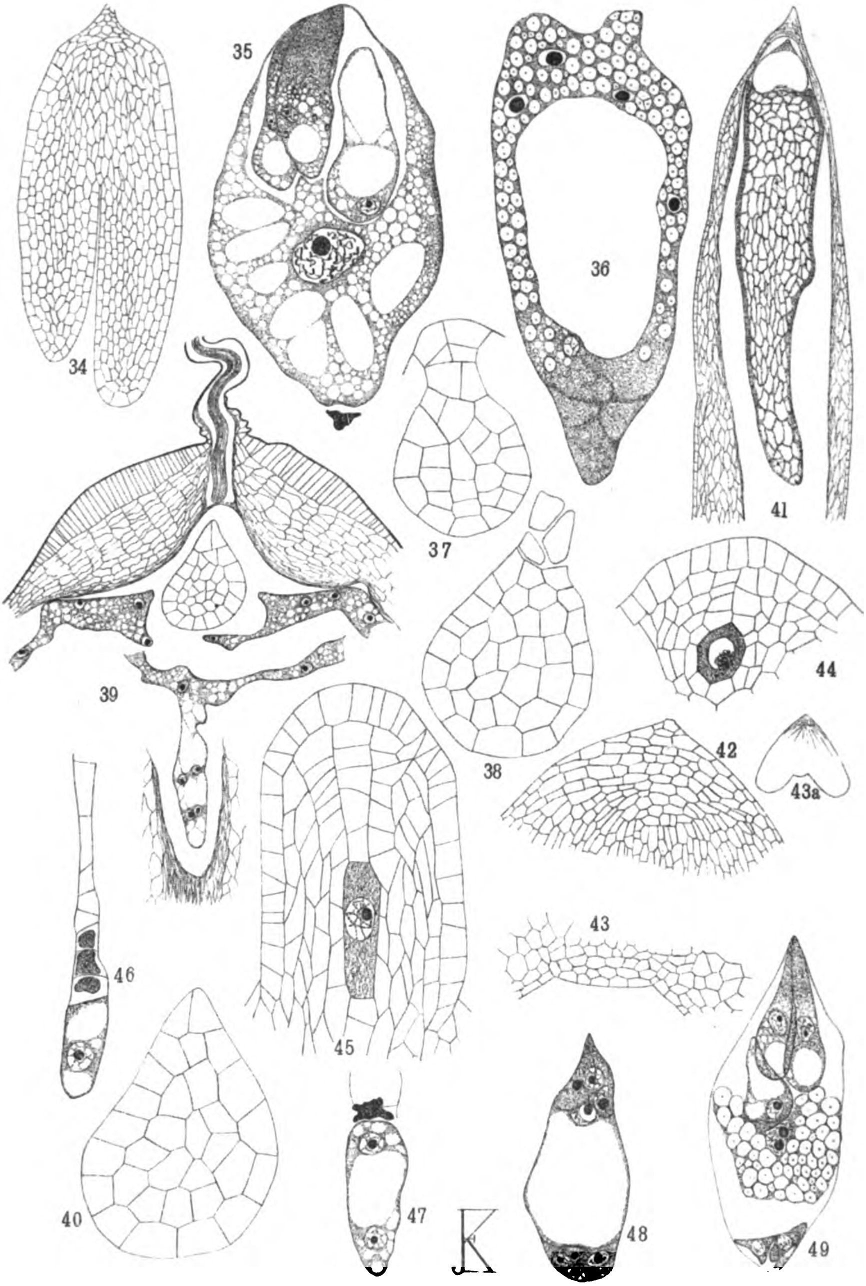

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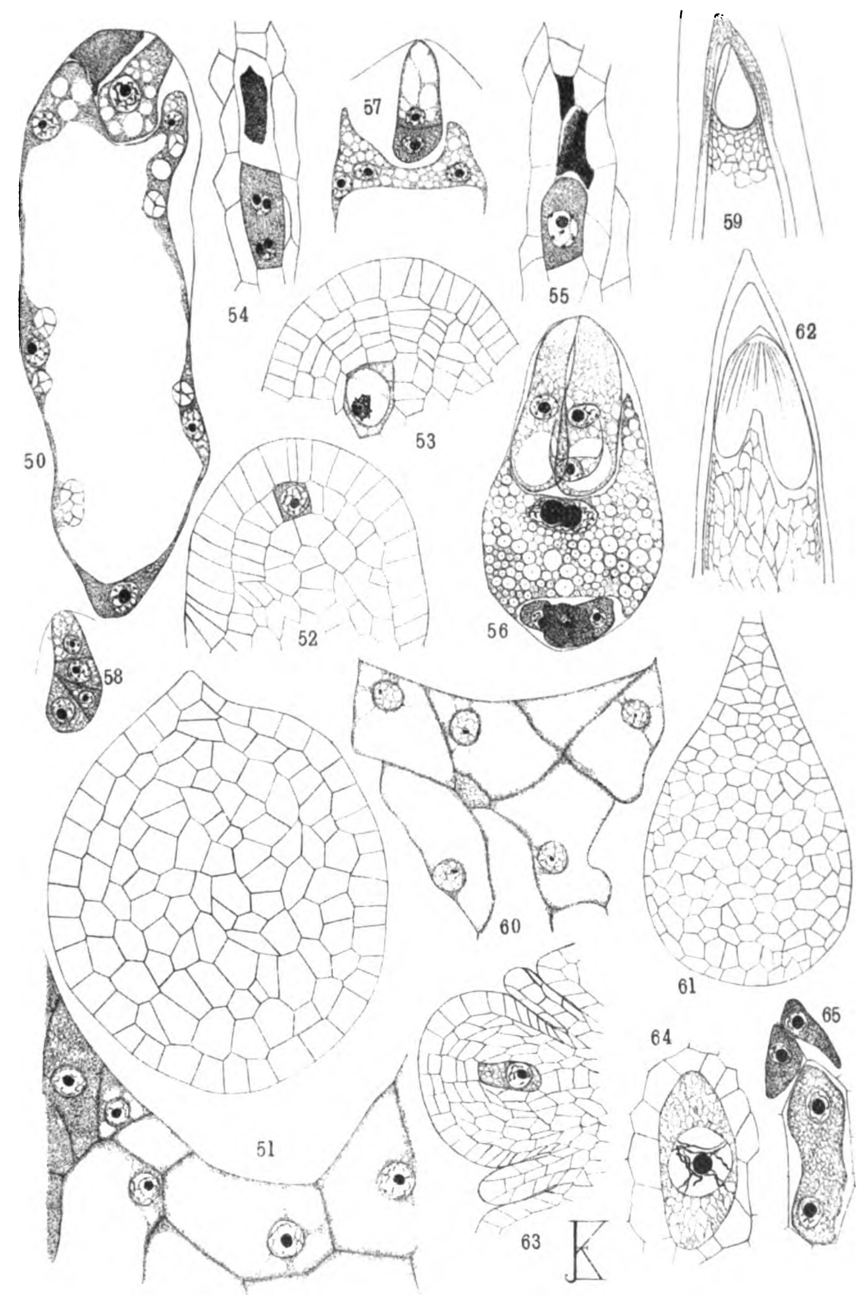
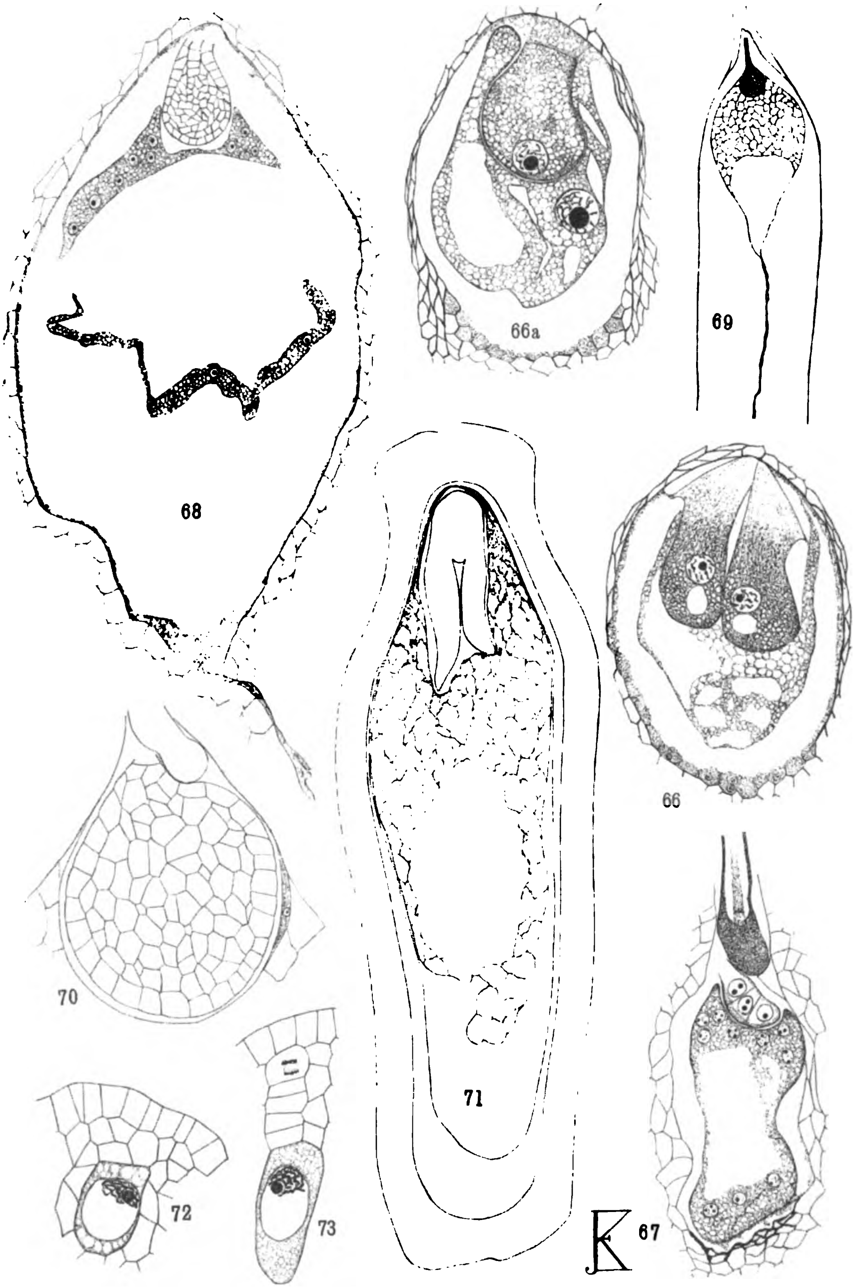
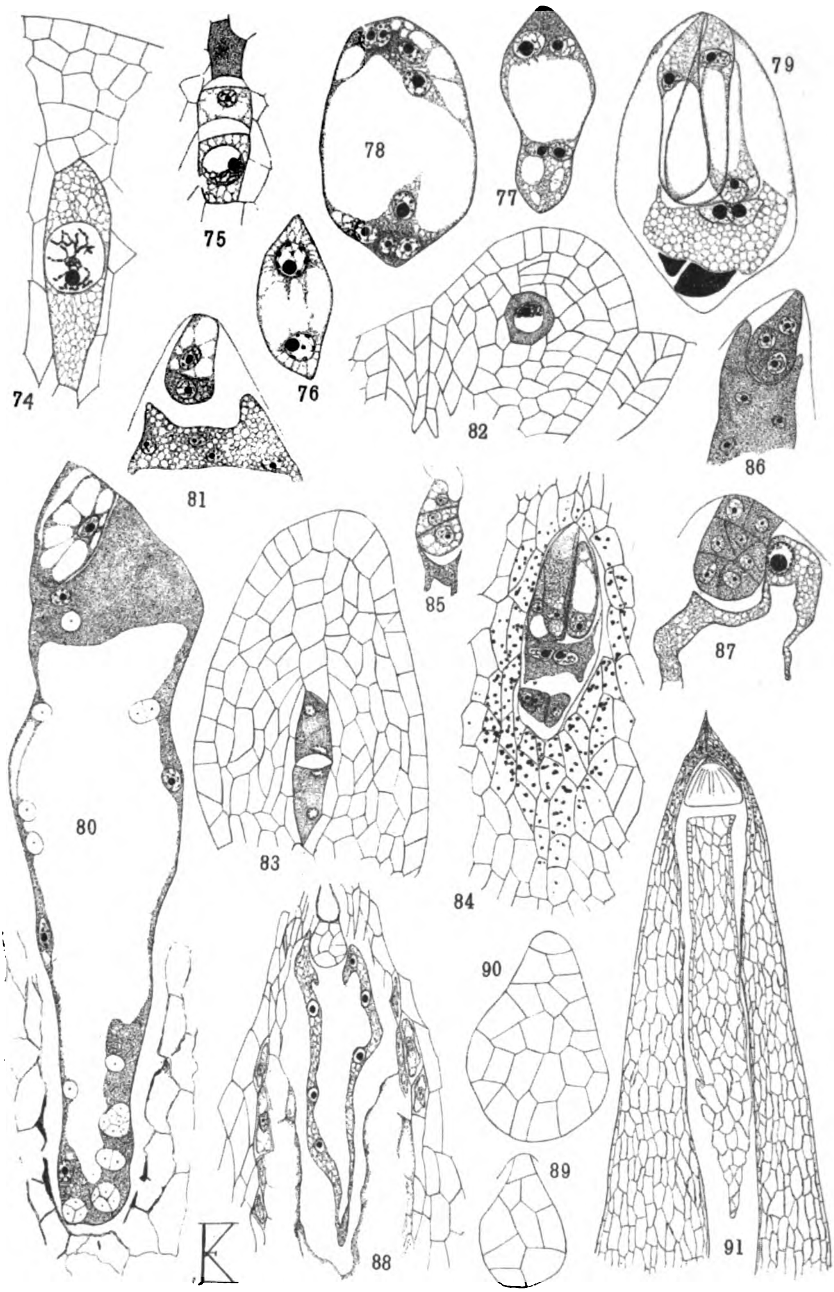
44-49. BRYONOPSIS LACINIOSA.



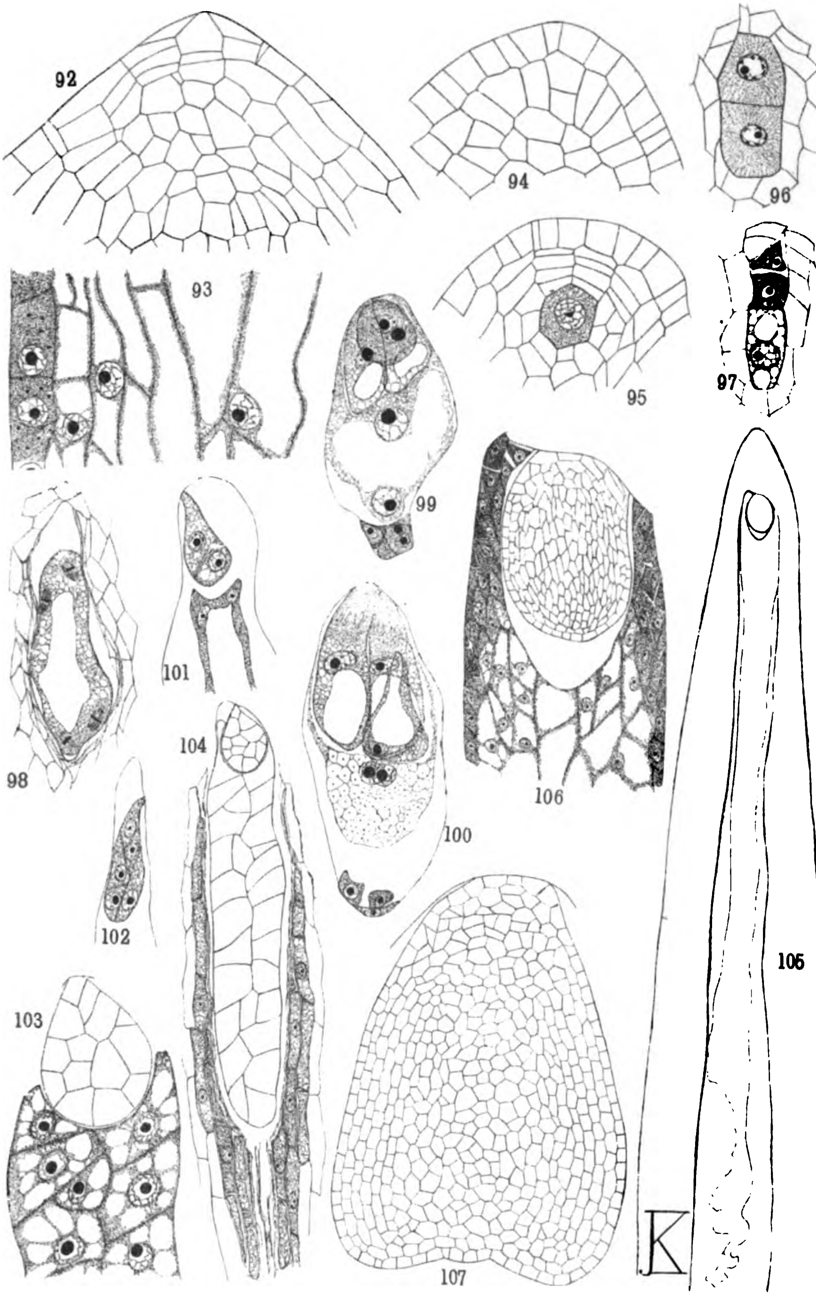
50-51. BRYONOPSIS LACINIOSA. 52-62. TRICHOSANTHES ANGUINA.
63-65. MOMORDICA CHARANTIA.



66-71. MOMORDICA CHARANTIA. 72-73. LUFFA ACUTANGULA.



74-81. LUFFA ACUTANGULA. 82-91. CUCUMIS MYRIOCARPUS.



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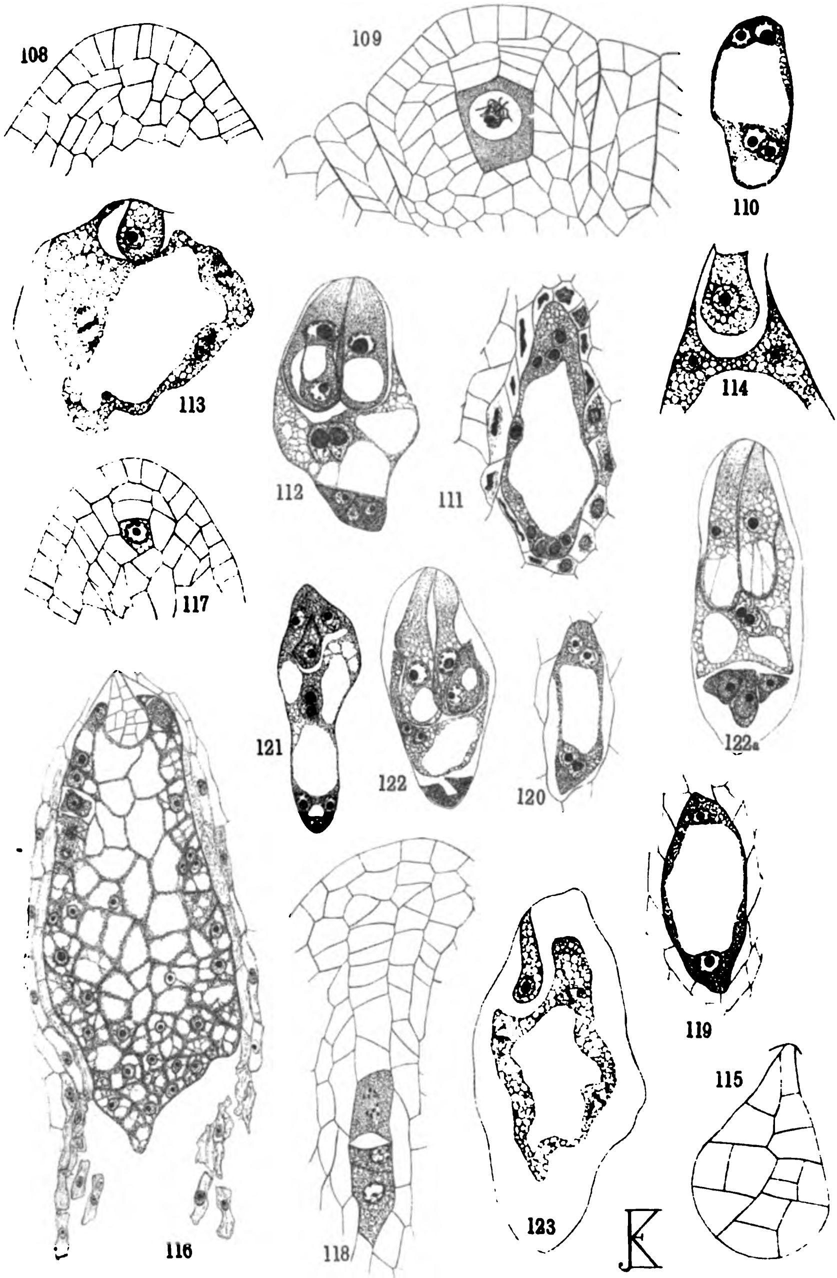
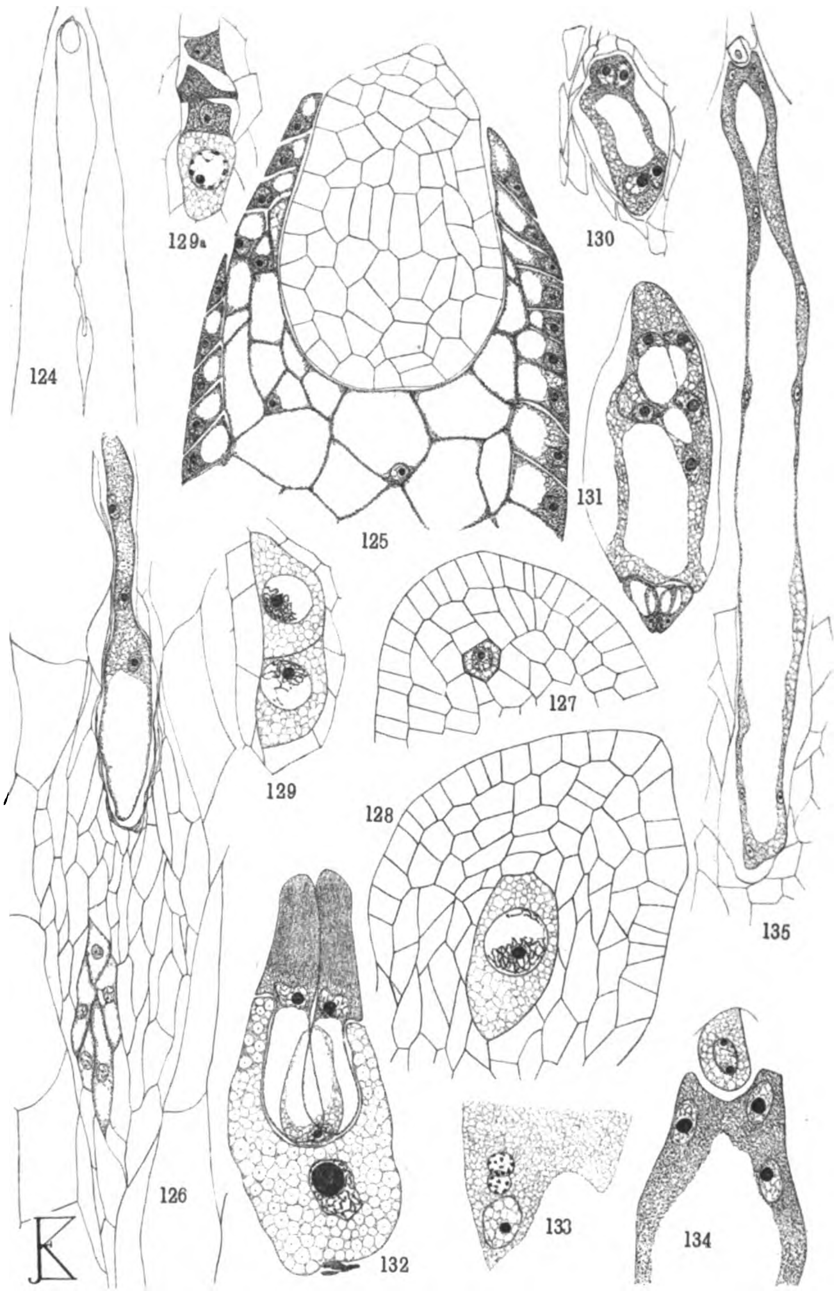


108-116. BENINCASA HISPIDA. 117-123. CITRULLUS CITRULLUS.



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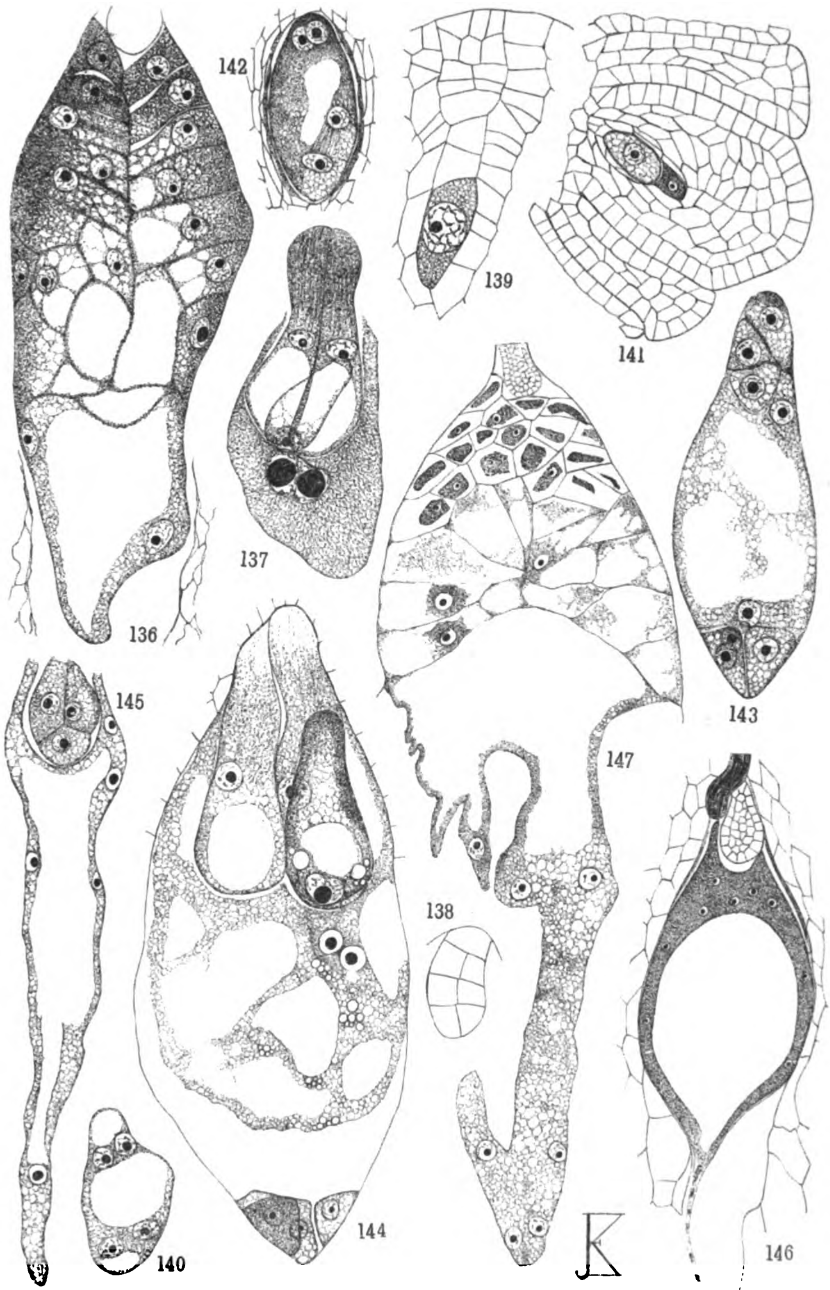

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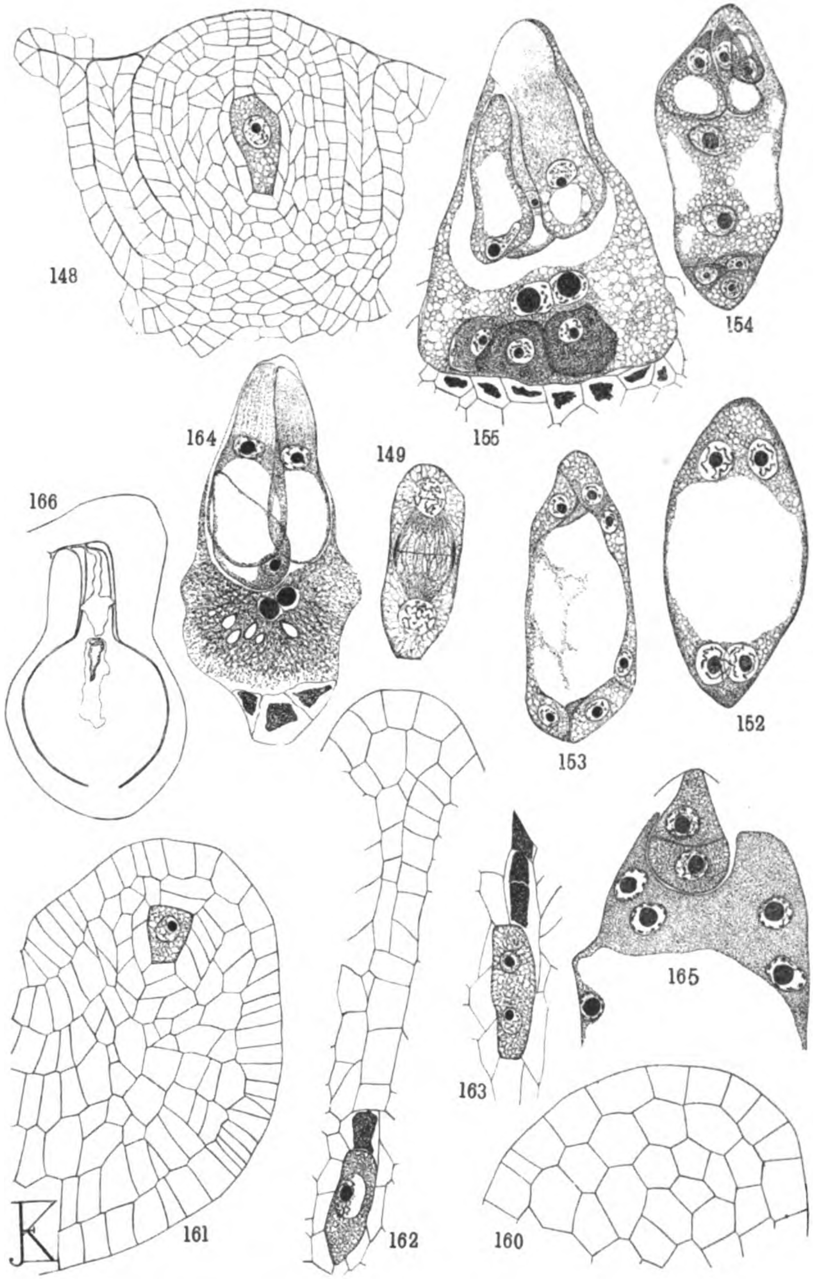

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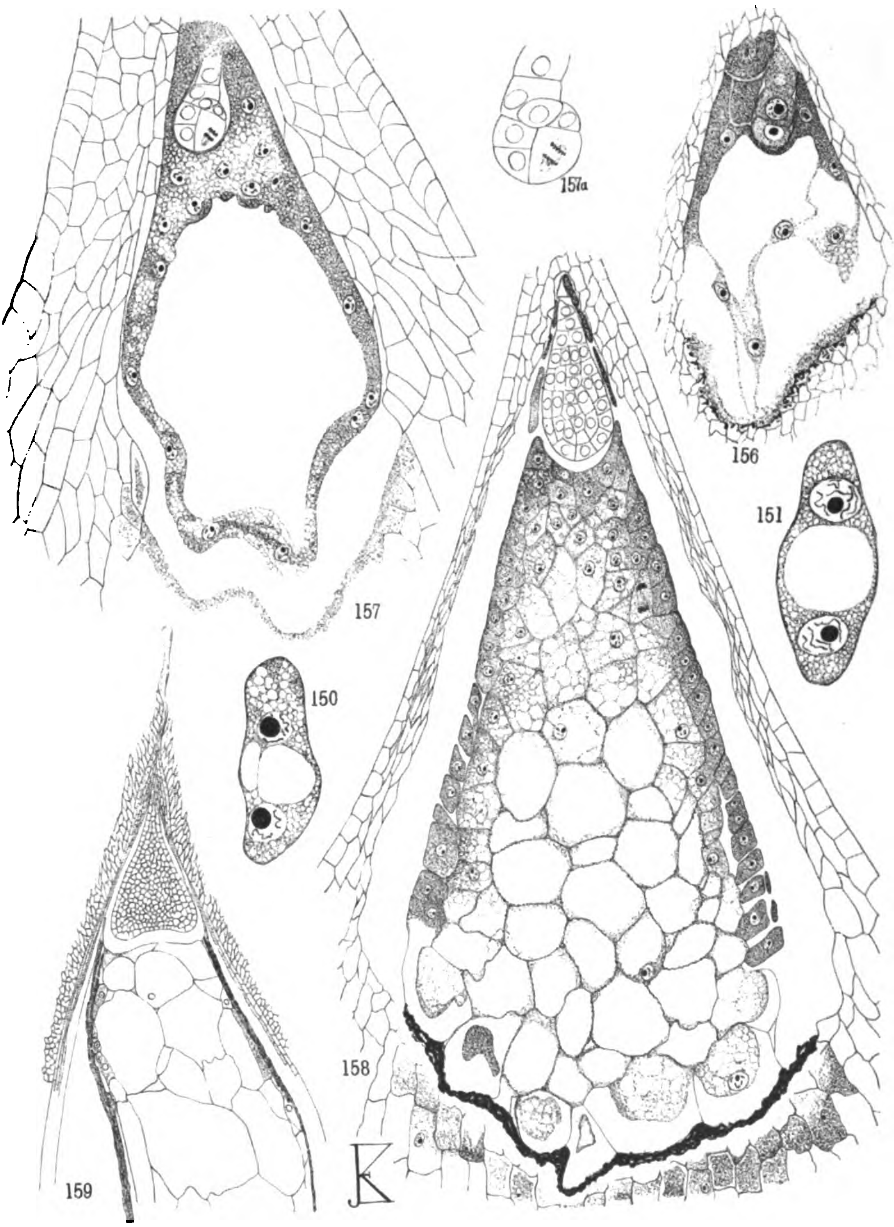
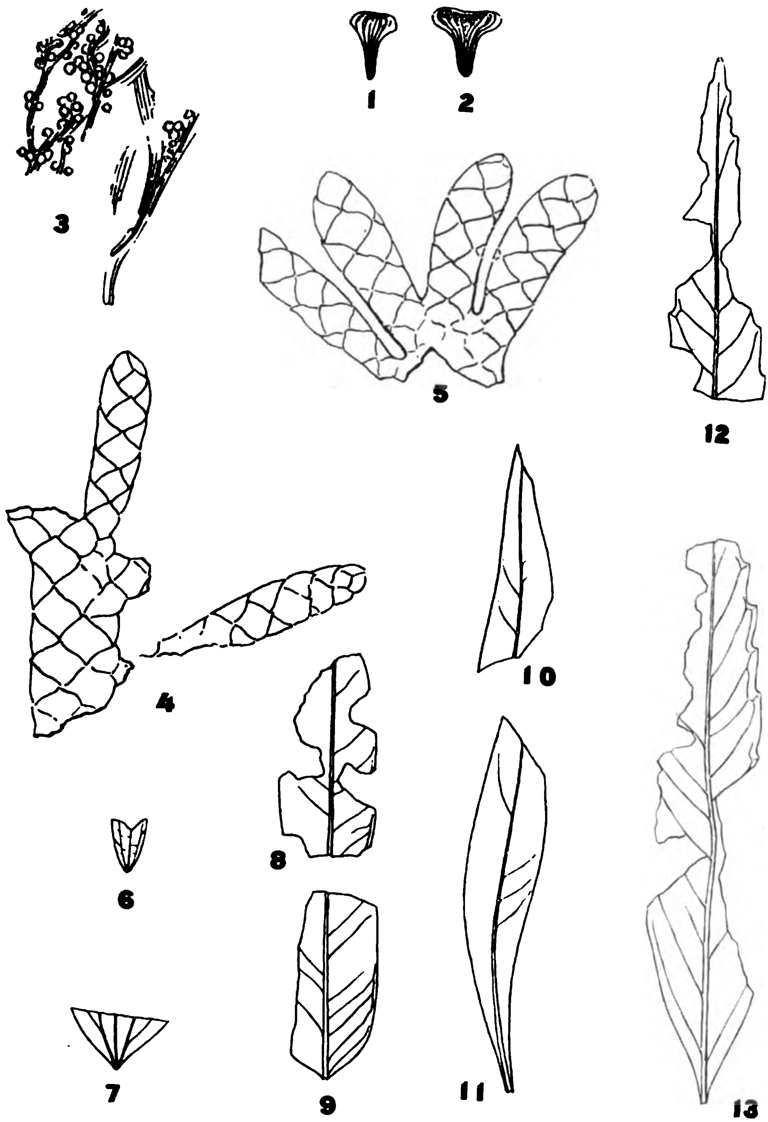


150-151; 156-159 MICRAMPELIS LOBATA.



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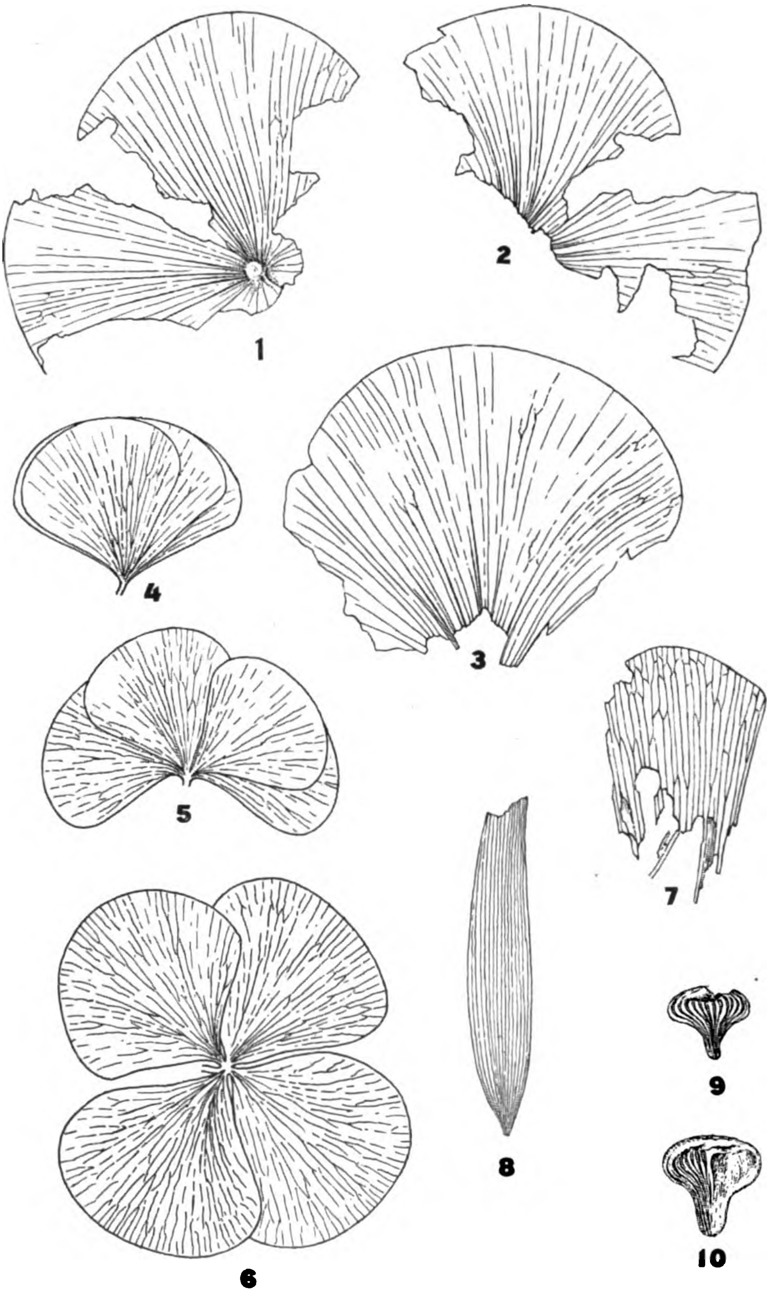

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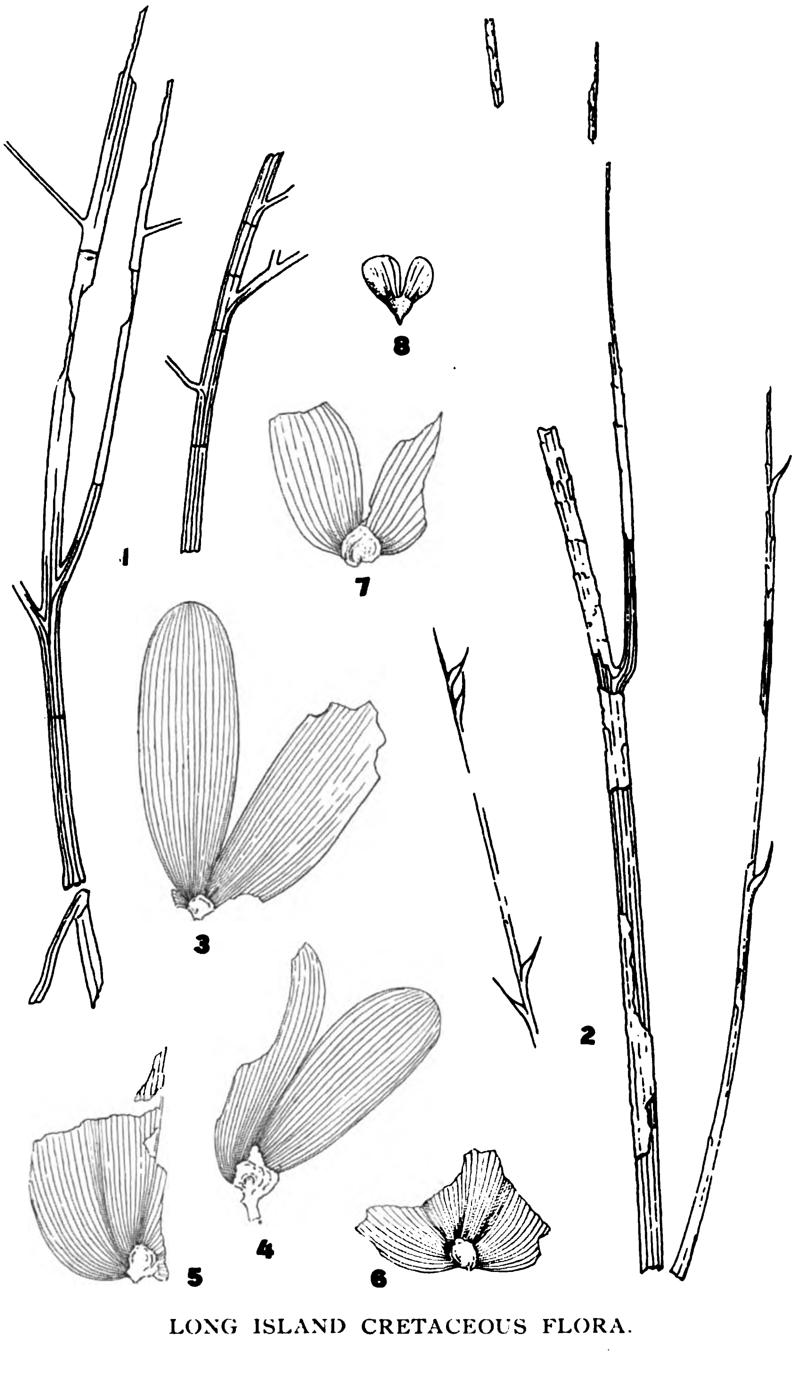

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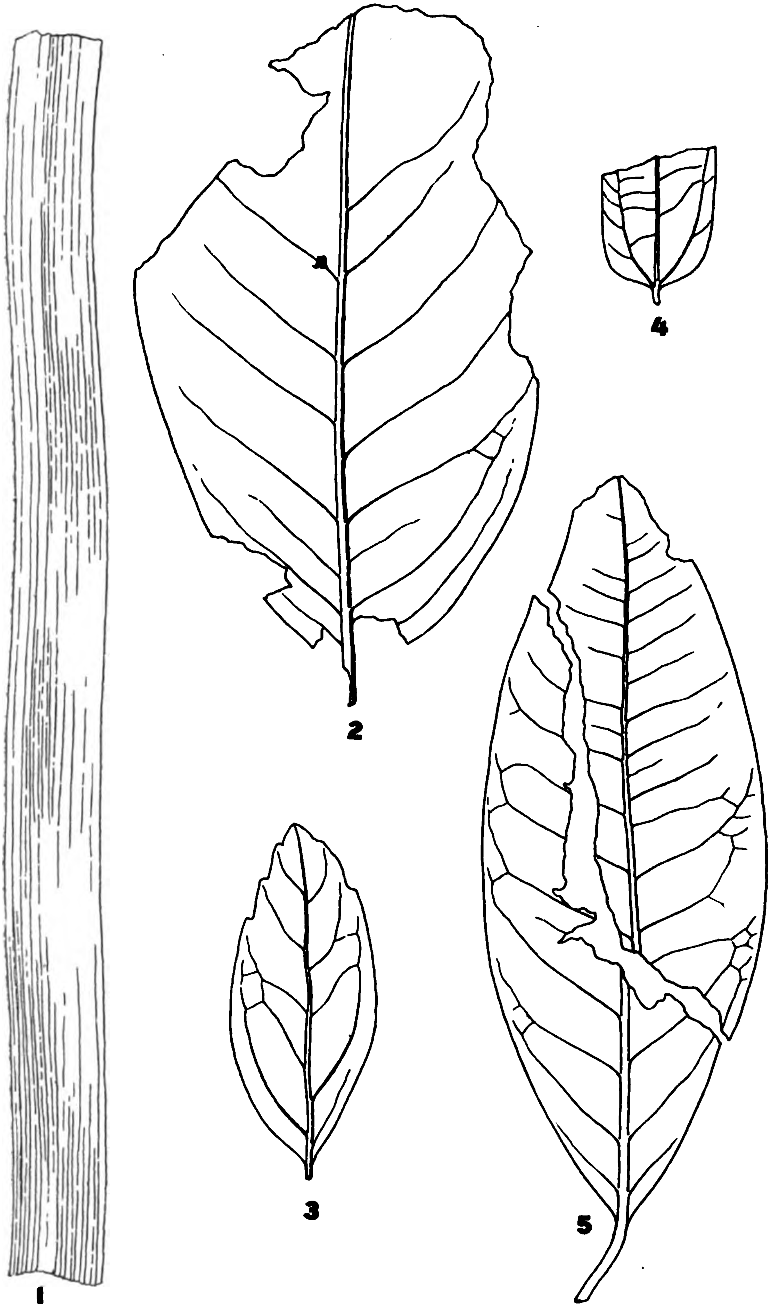

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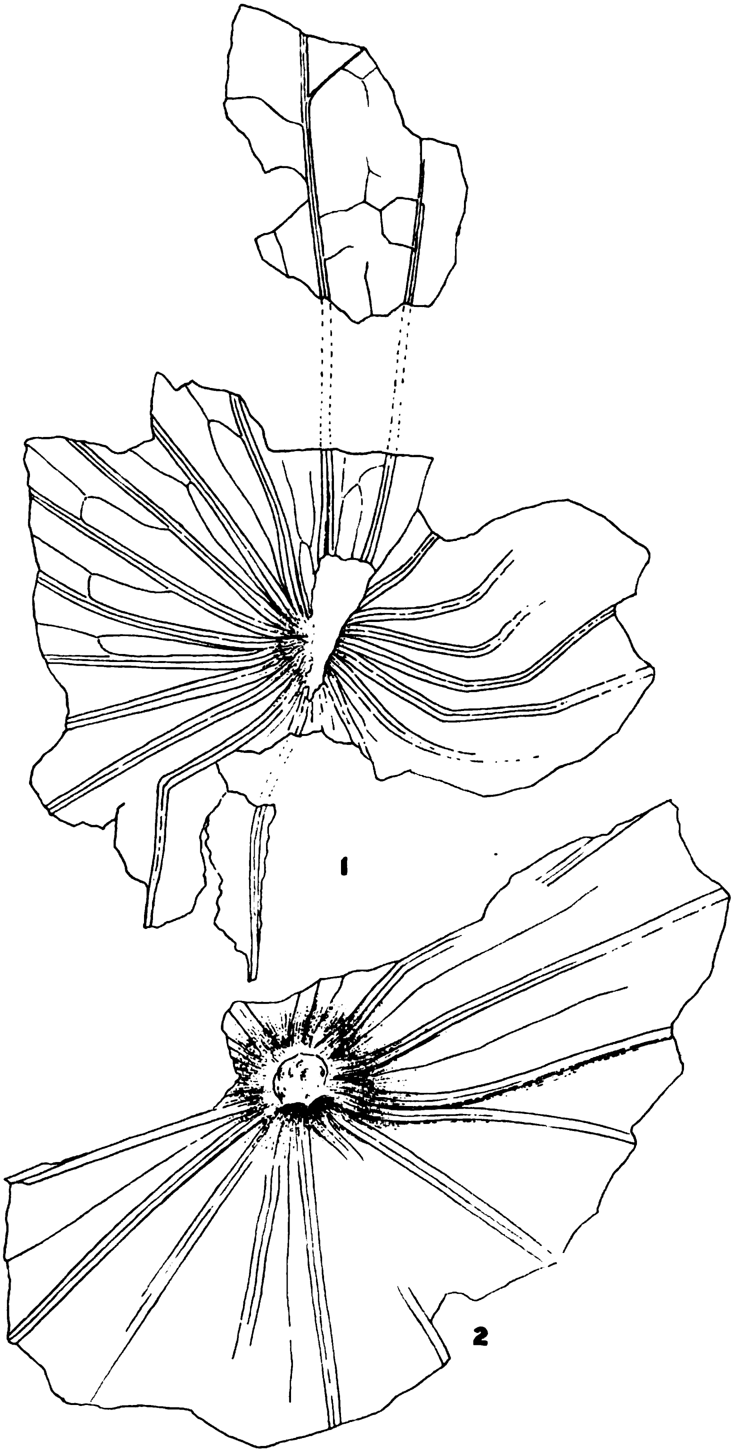

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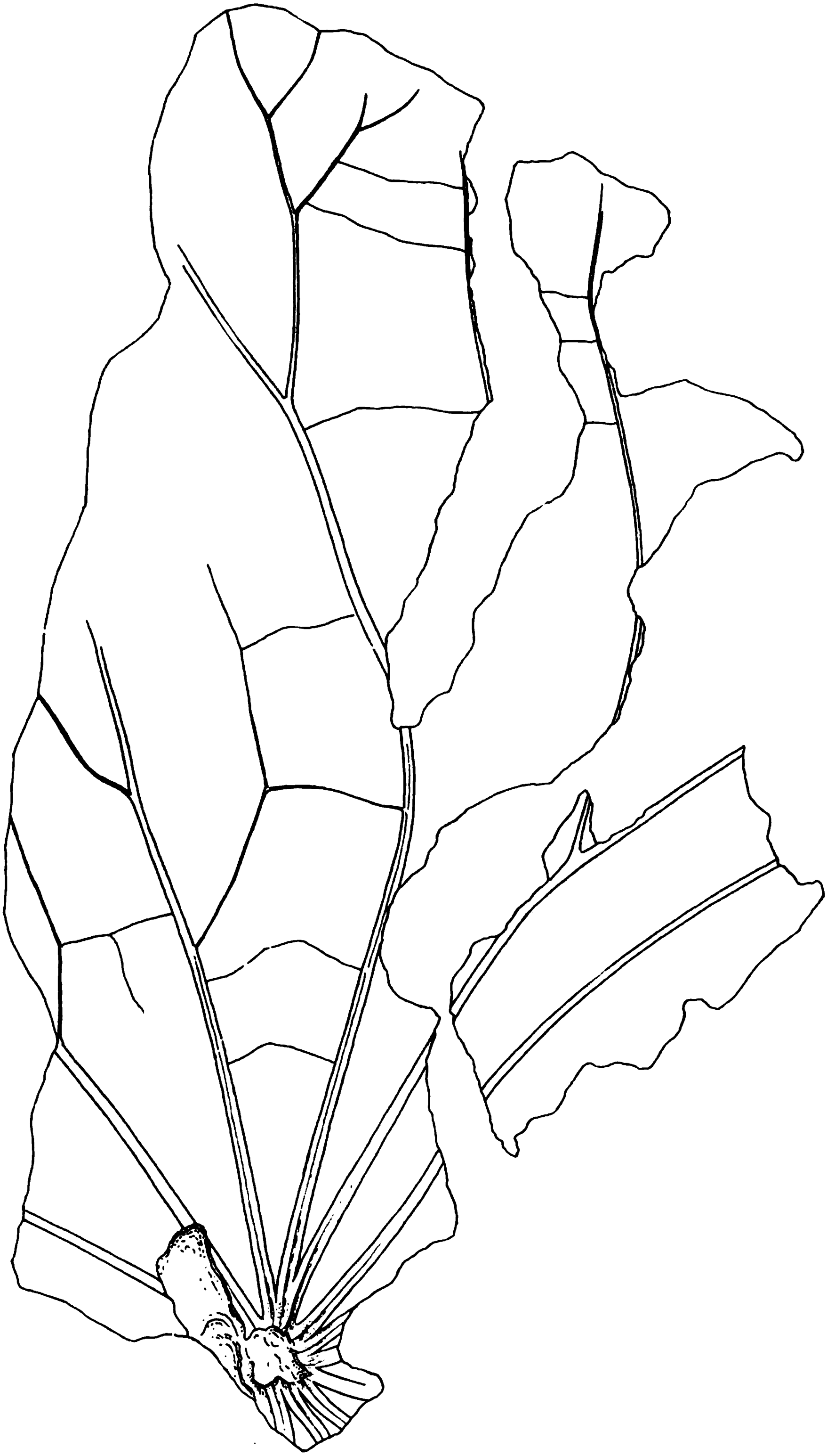

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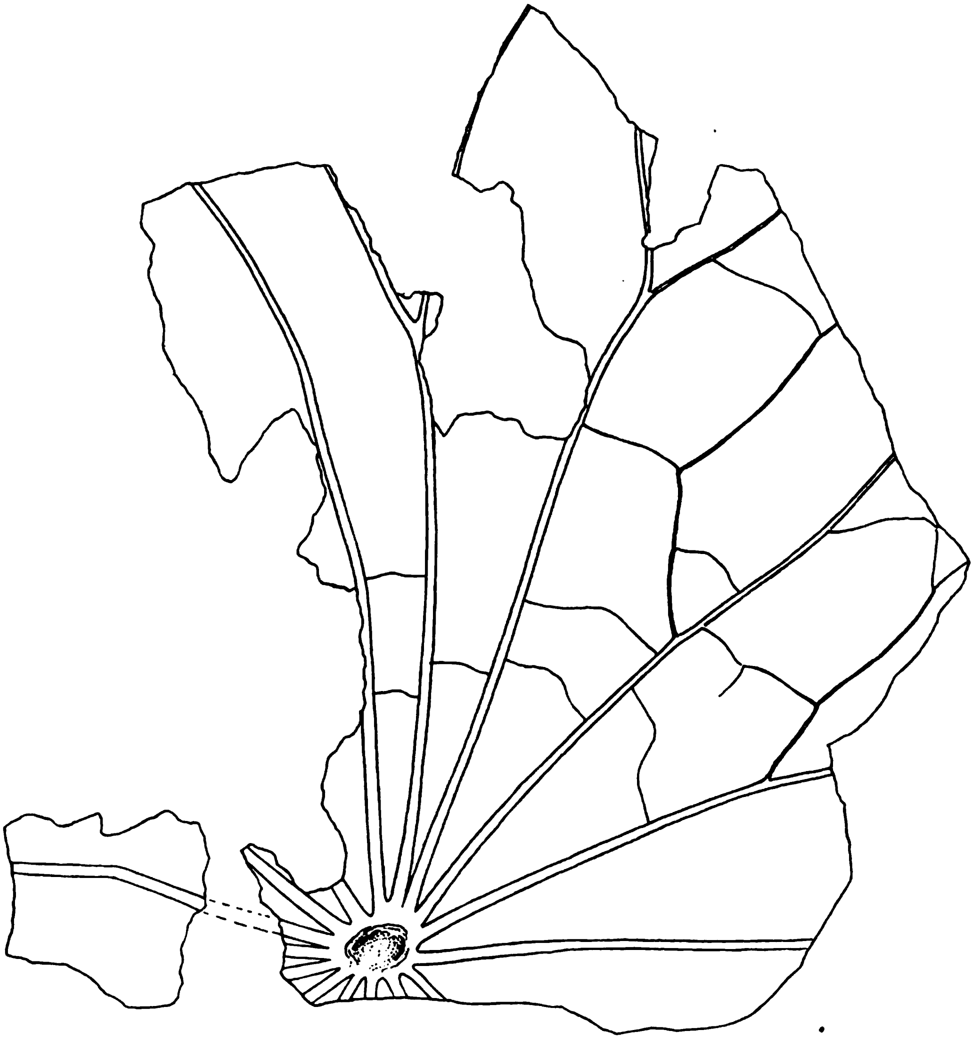

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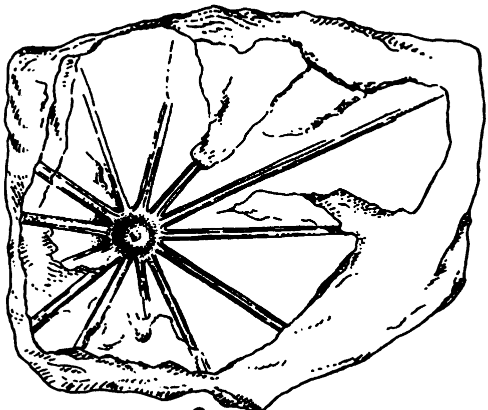

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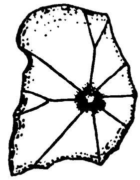

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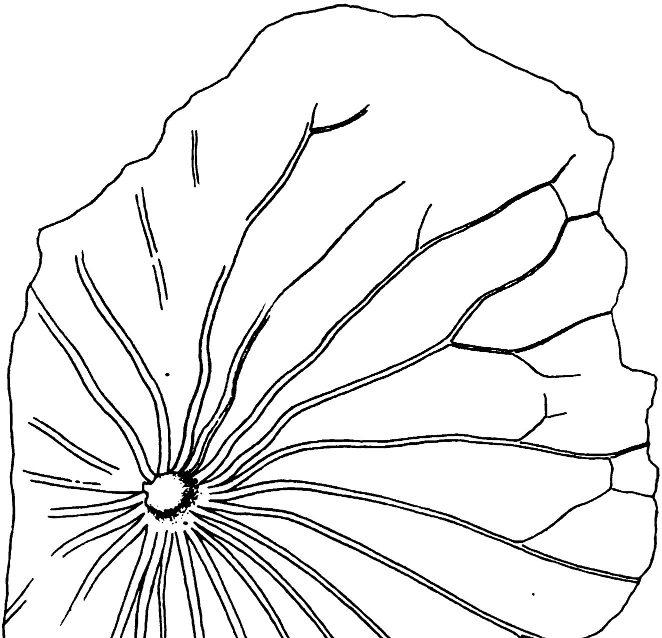

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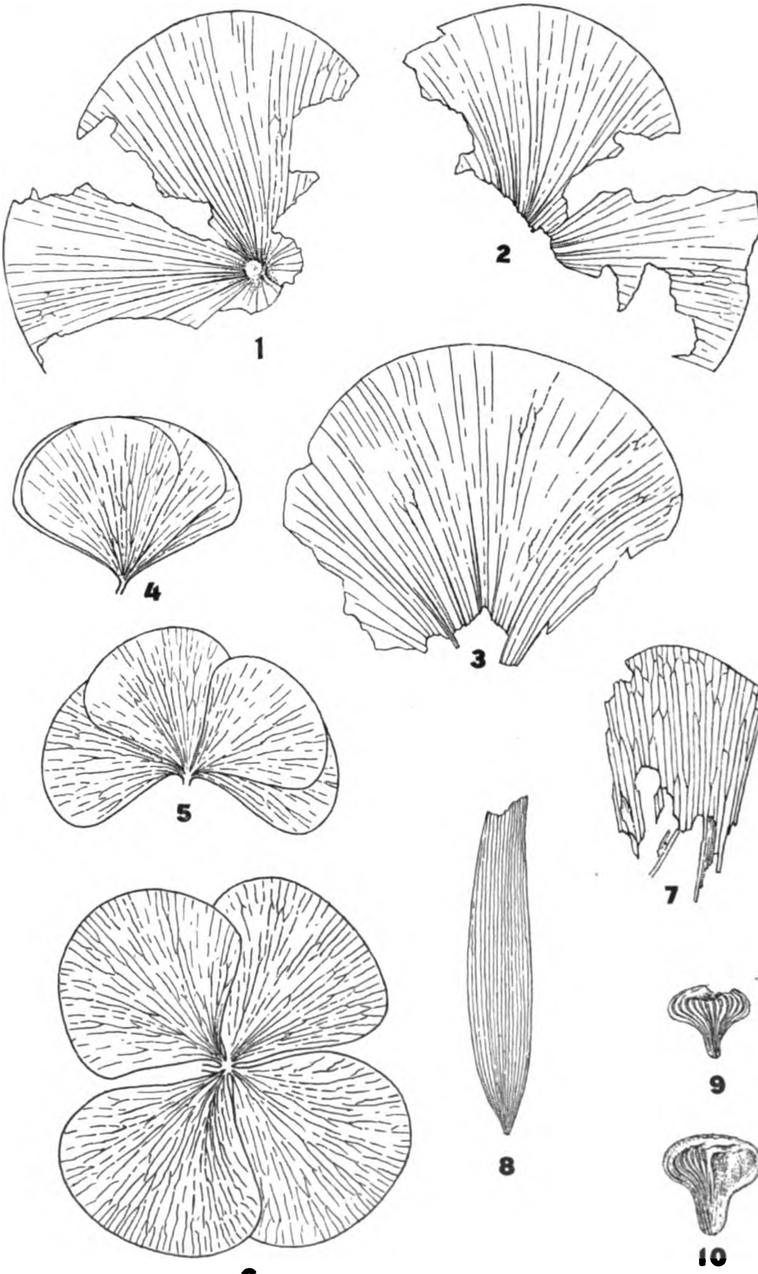

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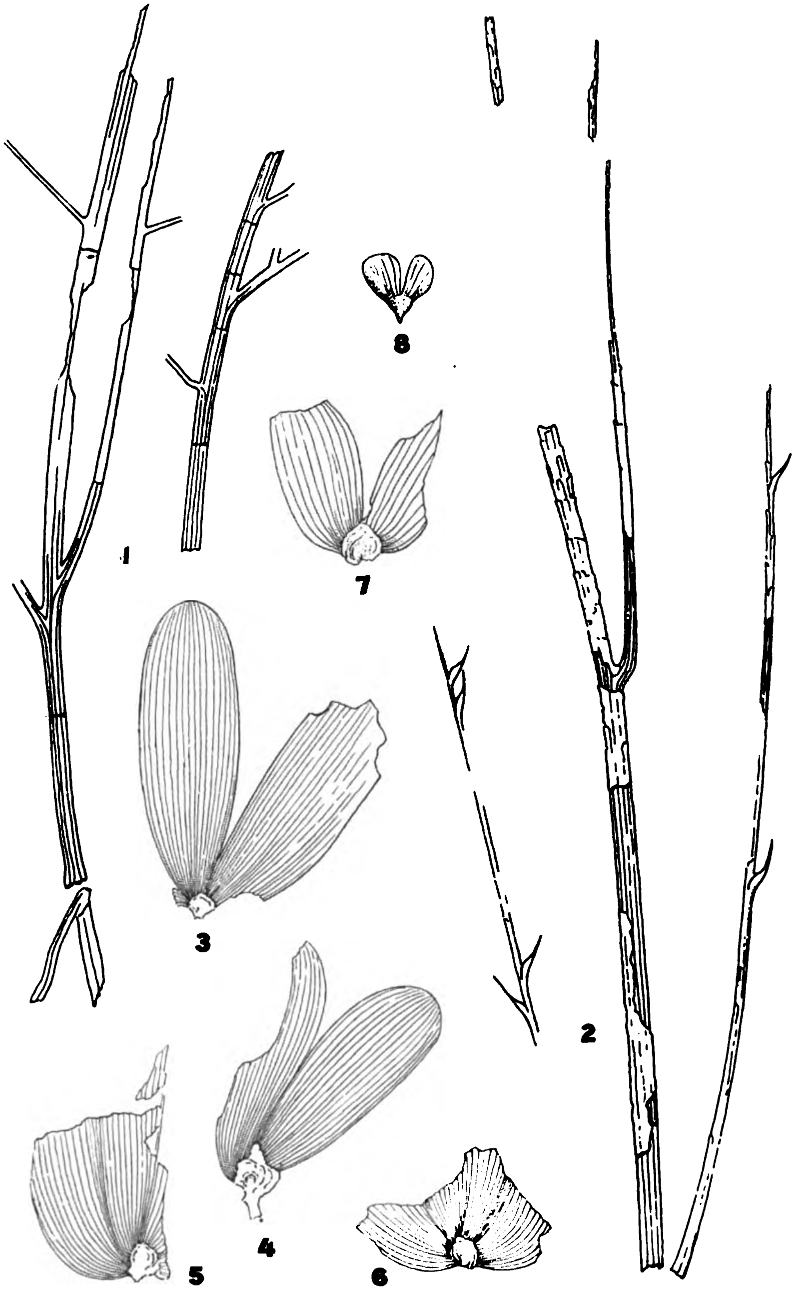

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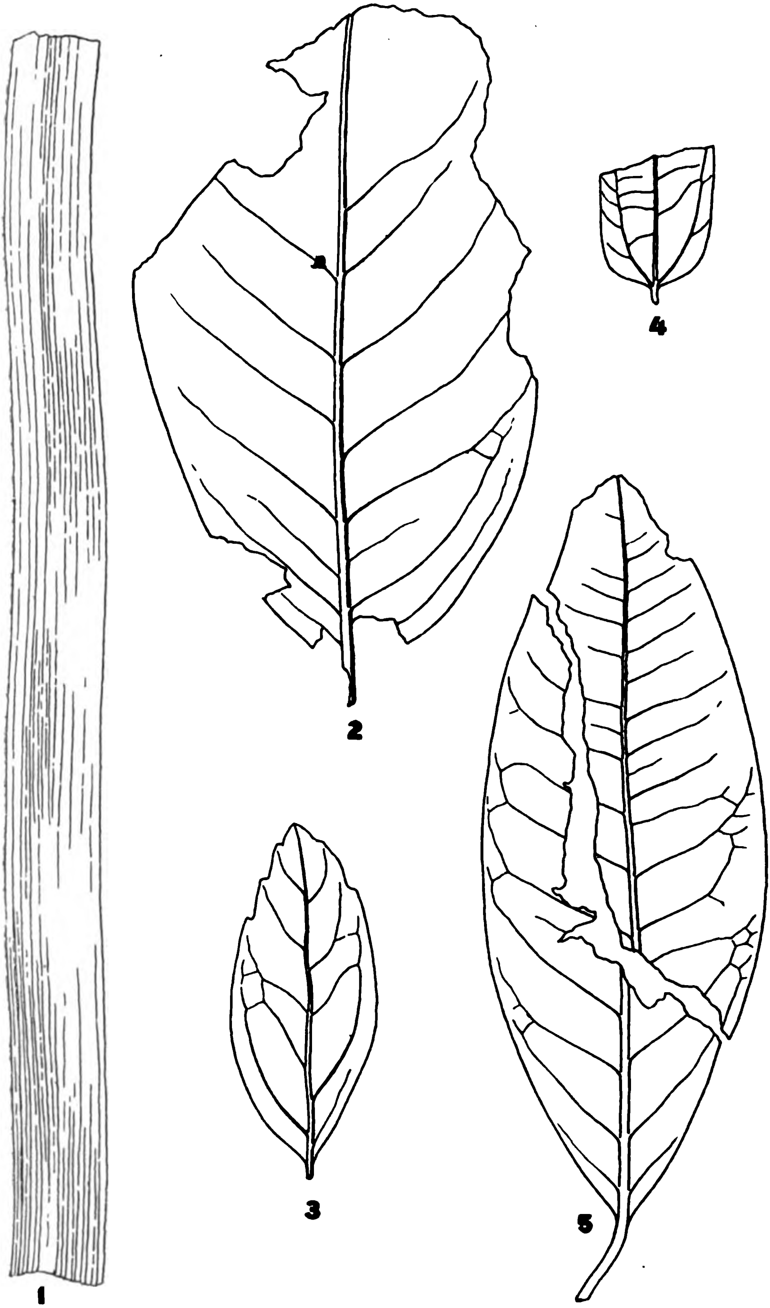

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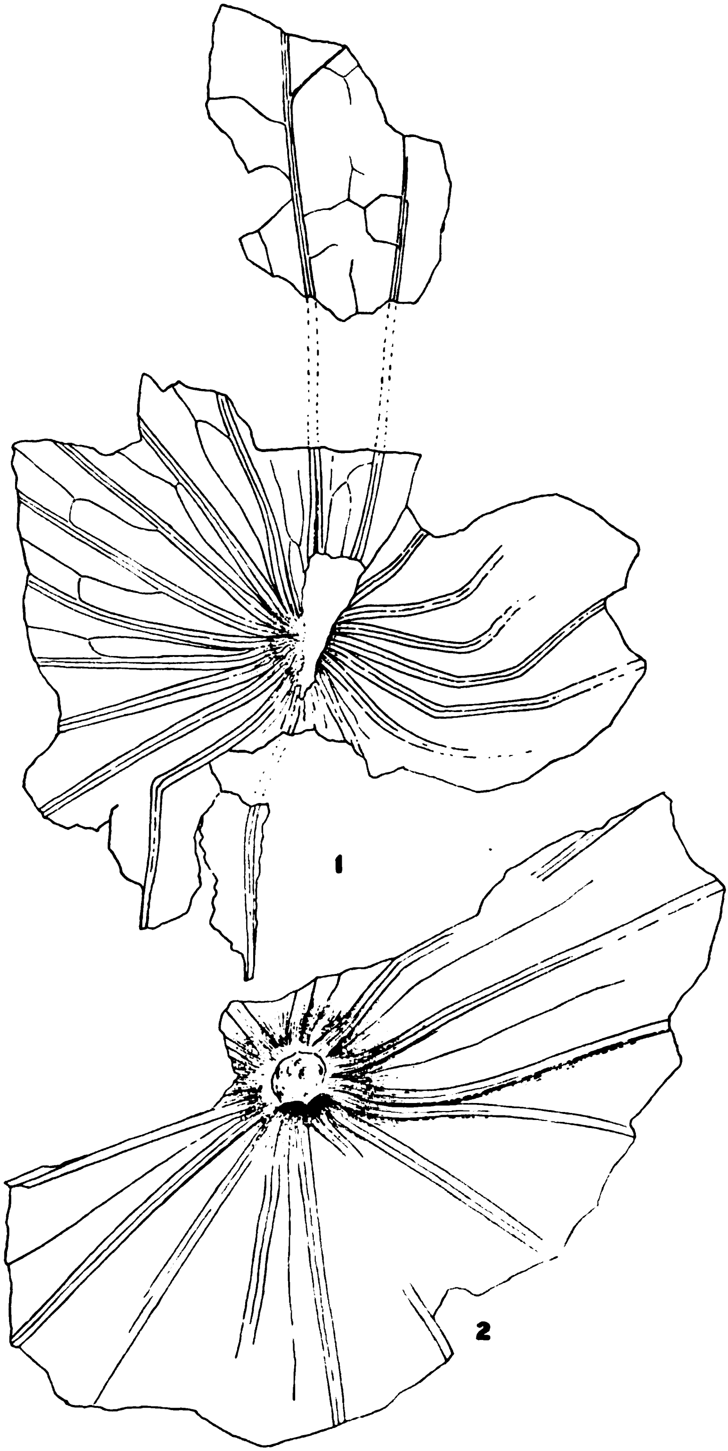

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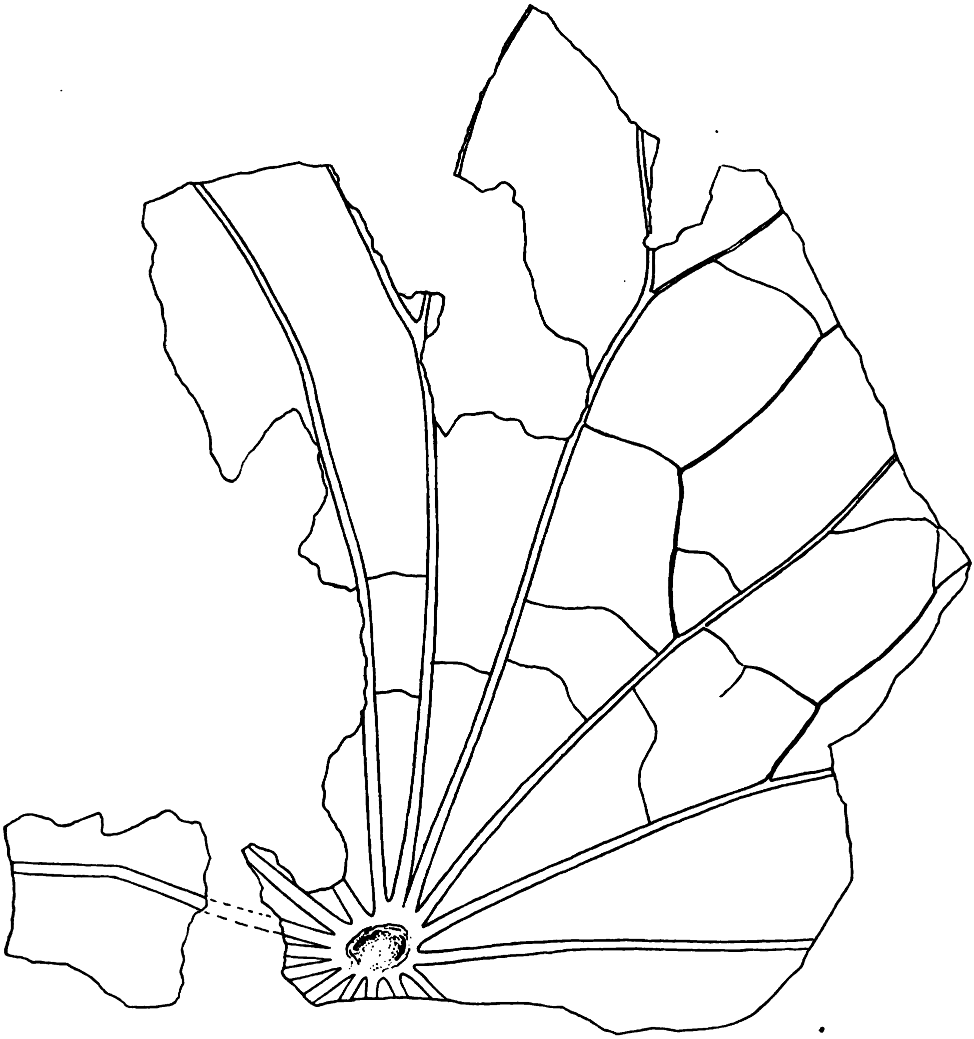

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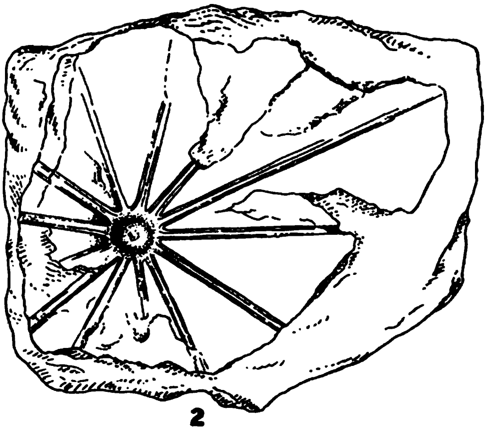

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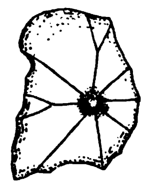

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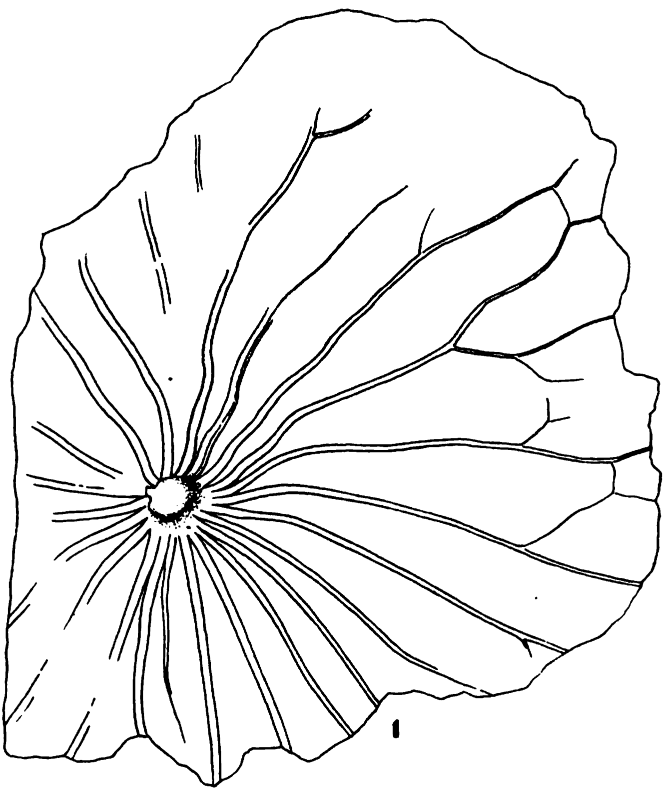

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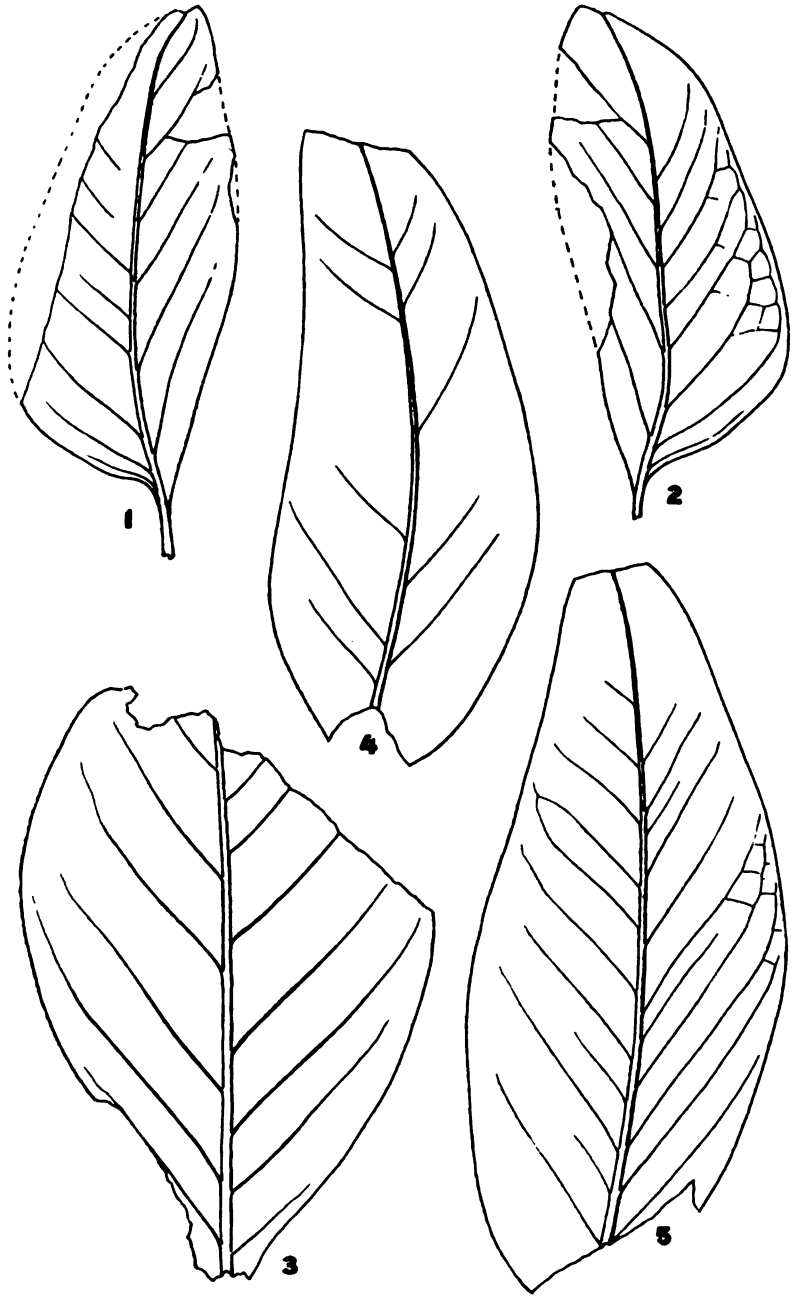

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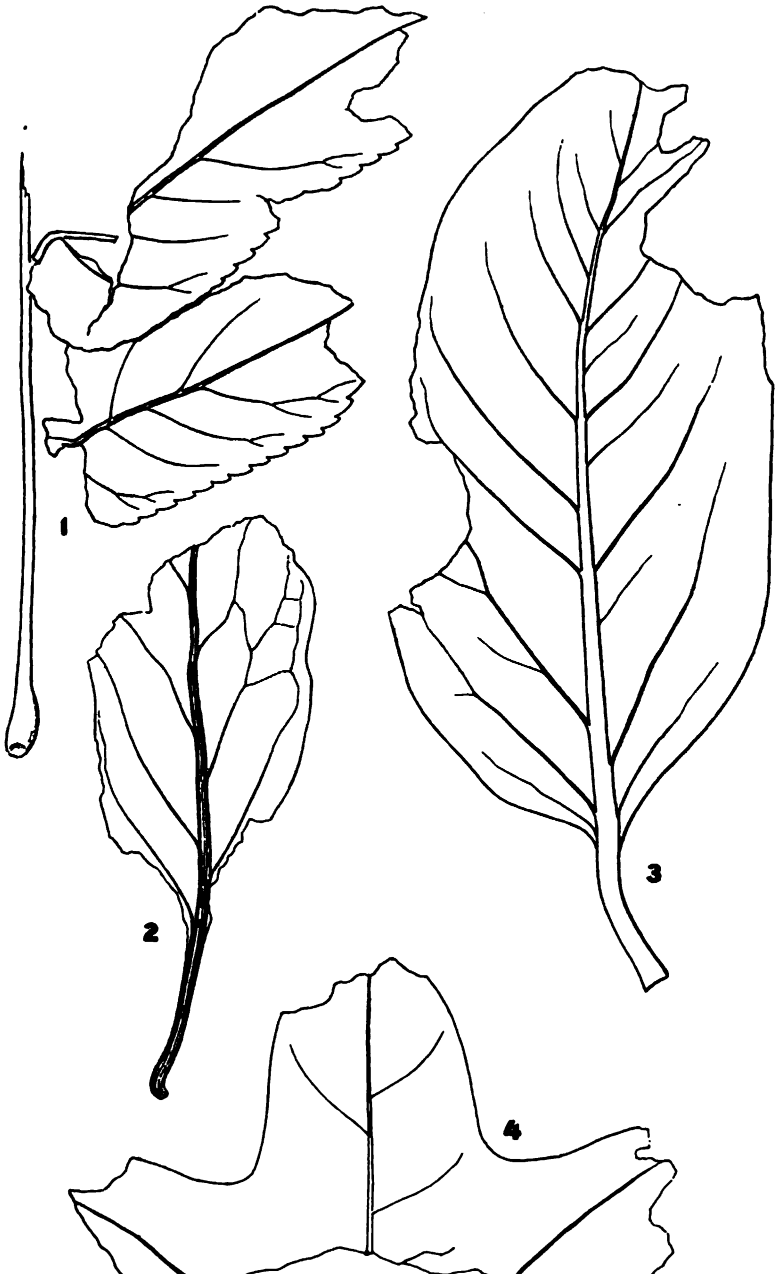

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